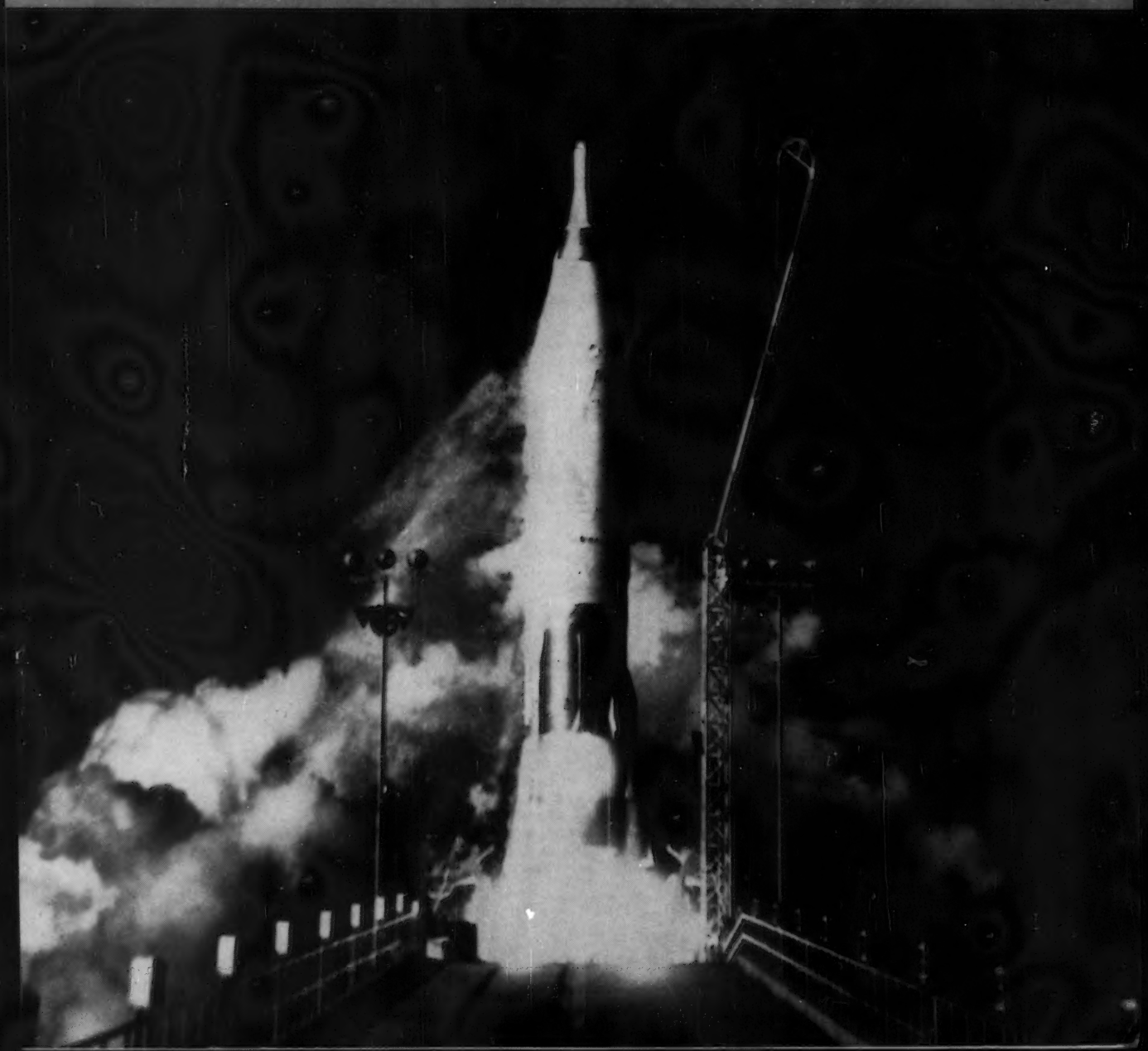
AIRCRAFT & MISSILES

A Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES February, 1960

How Navy Will Monitor Polaris Firings...P 22

SPACE-AGE ADHESIVES—A SPECIAL REPORT . . . P 34

Details of Atlas' Ablation Nose Cone Revealed . . . P 40



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The Chatham Y-Series answers your design problems especially when you're confronted with those tough aircraft space-weight restrictions. Write now for the new bulletin describing the Chatham Y-Series and other airborne power conversion equipment. Chatham Electronics, Division of Tung-Sol Electric Inc., Livingston, N. J. Sales Offices: Culver City, Calif., Dallas, Texas. TWX:NK193.

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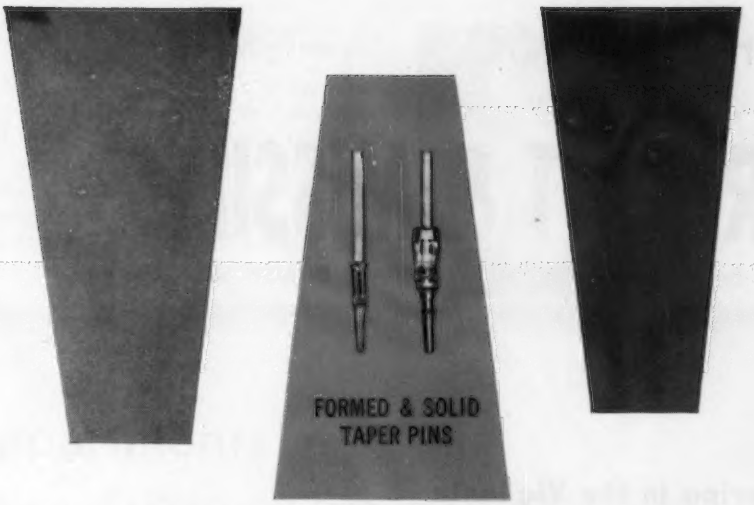
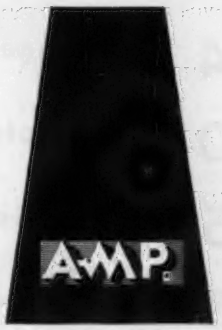


FOR A TIGHT FIT IN A TIGHT SPOT...



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February, 1960 *Volume 3, Number 2*

AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

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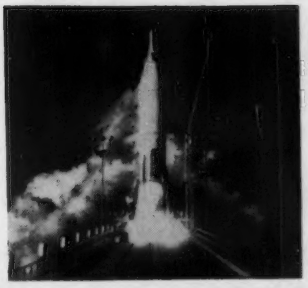
THE COVER STORY

The Mk-3 ablation nose cone is successor to the copper heat-sink. Shown rising atop Atlas in the cover photograph, this nose cone will soon be operational with the missile. First details on material (nylon reinforced phenolic) and method of construction (tape winding) are given in staff written article on page 40.



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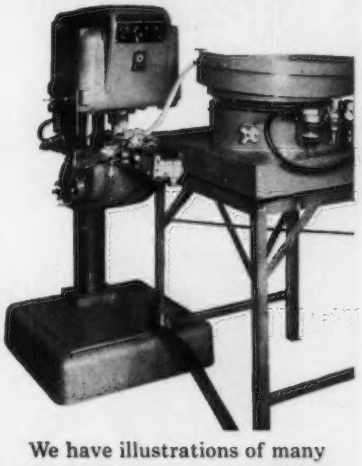

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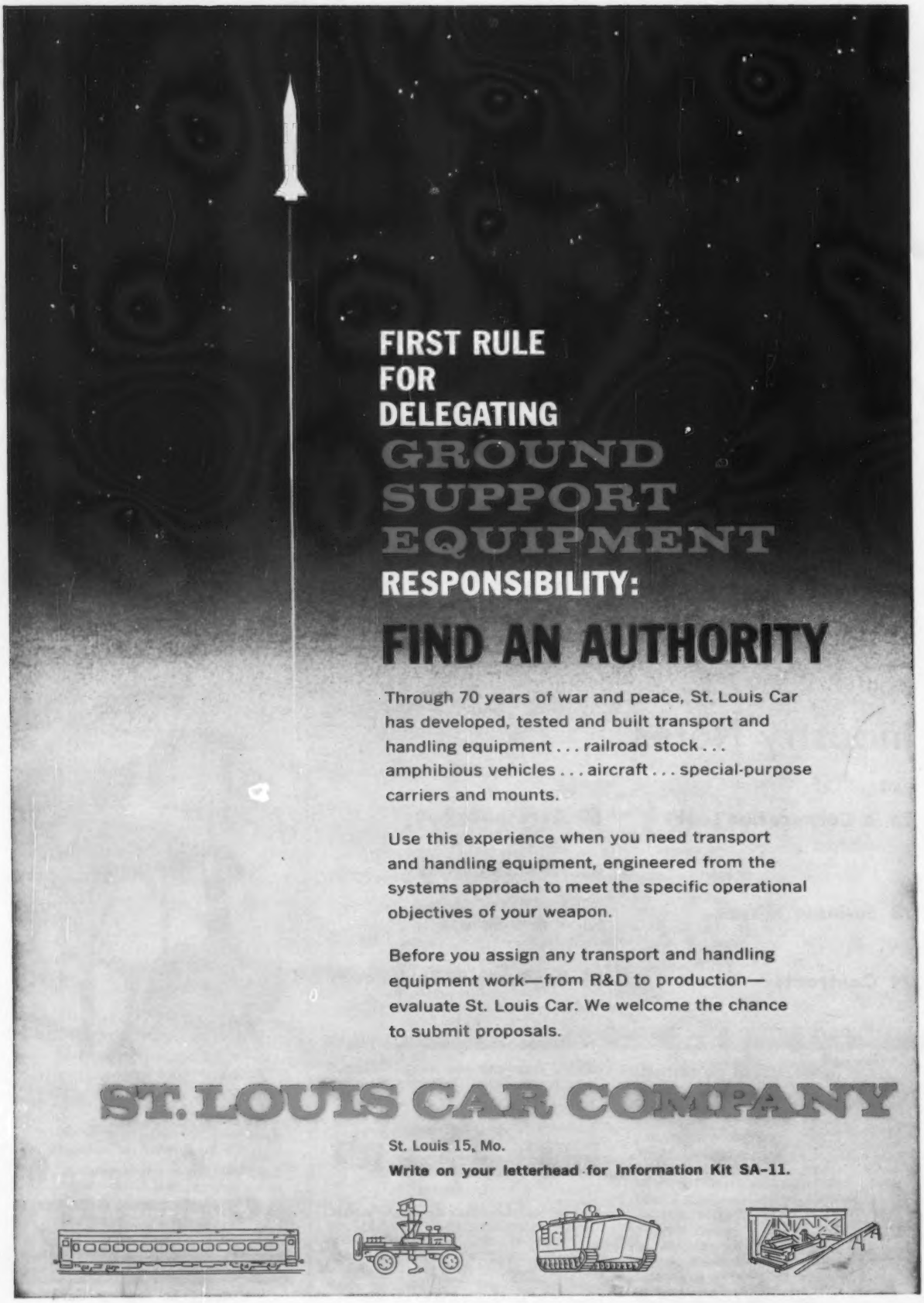
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Can We Have Progress Without Failures?

Stuck with a bad hardware decision? Being blasted for it? Probably not your fault. Just another complex problem in this constantly changing missile business.

Let's take a case. A prime selects a subcontractor to make a nose cone at the start of a project. Selection of the sub is usually based on the reputation and claims made by the sub. Then, as the project passes down to the test phase, with a host of mission or design changes, everybody has problems. The material doesn't come up to spec in certain new environments. In our case, it's a cold shrinkage problem. Yet, up to this point the material tested out fine. It was a logical selection in the "go-ahead" stage. Why? Simply because the prime made the selection on the "best information available."

At this stage of the game, the people who made the original decision are sweating blood. It's too late to start from scratch. This would mean a re-test in all environments with the possibility of failure at any stage. Also, there's too much money wrapped up already. Too many things hinge on the original plan since under the "concurrency" concept most other items are based on the now "deficient" material.

Solution now is to keep going and get the situation straightened out. This costs dough. Money not in the original plan. The project is no longer orderly; work on other phases slows down till the bugs come out of the nose cone.

Okay, so what do we do about such everyday problems? One solution is easy. Just don't let people change their minds once a contract is awarded. Another solution is difficult and not one easily met. Put one genius at the head of each project in its preliminary stages. All this man has to do is think of ALL the problems that will be encountered during the project's life. Let's not kid ourselves; these "solutions" just aren't practical.

One thing we can do is stop persecuting the people who make decisions, when they act on "best information available." Remember, today progress is swift but it has never come without failure.

Tom MacNew
Editor

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SPIN FORGE TO 120" ON NEWEST HUFFORD GIANT

The largest Spin Forge facility in the United States (currently producing surface-of-revolution parts up to 72" diameter), Hufford, El Segundo, will soon place in operation a new "four story" unit capable of forging hardest metals to 120" diameter and beyond...30 feet in length. Designed, built and wholly owned by The Hufford Corporation, this massive, fully automated machine, together with complete engineering service and production follow-through, will be available to simplify parts production for you by midsummer, 1960. Outstanding advantages of the Spin Forge process include marked improvement in material grain, elimination of welding seams... production of parts heretofore considered difficult or totally impossible. Complete information will be sent in answer to your request to: The Hufford Corporation, 1700 E. Grand Ave., El Segundo, Calif.

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INTERNATIONAL AMPHITHEATRE

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Reader's Orbit

Air Force Likes Handbook

As a member of the Missile Panel for the Eighth Air Force, I have been assigned the task of compiling a Missile Directory and Data Booklet . . . the presentation made in your 1959 Annual Handbook Issue is the best non-classified directory I have seen . . . would appreciate permission to reproduce those portions of pages 19 through 30 that are applicable to the Missile Panel's use. The publication will be for official use only, and will be distributed throughout the Eighth Air Force . . . distribution will be 500.

Lt. Col. Edmund W.
Edmonds, Jr.
Headquarters Eighth Air Force
Westover AFB

Permission granted. However, you may wish to wait for the 1960 edition which will appear in March.

High Nuclear Interest

. . . Several of the technical engineers at General Electric are extremely interested in your articles covering the atomic aircraft and nuclear power in the December issue of A&M. Would you please send six copies of the following articles: (1) The Atom Powered Aircraft, (2) Direct-air-cycle Powerplant, (3) Nuclear Effects on Materials, (4) Why Nuclear Rockets? (5) Russia's Nuclear Aircraft, (6) Mach 3 Transport.

G. E. Billman, Specialist
X211 Product Evaluation
General Electric Co.

Industry interest in the atomic airplane has been overwhelming. The Bureau of the Budget unfortunately does not have similar interest. Engineering requests for reprints of articles in the December issue have passed the 200 mark . . . and they're still coming.

Bouquet From AIA

. . . Many thanks for the very excellent study which A&M has conducted on "Today's Aircraft-Missile Engineer." It is a very valuable document and one which will be of considerable use to us.

Burton E. English
Public Relations Dir.
Aerospace Industries Assoc.

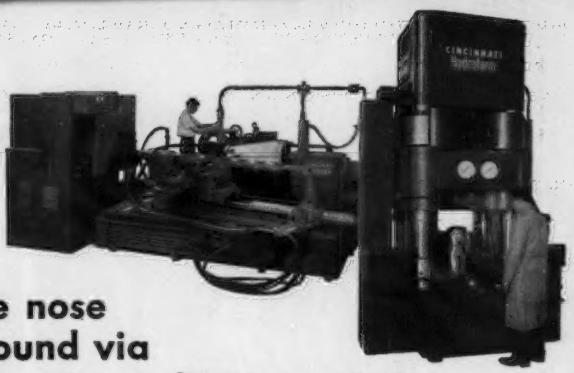
Circle 9 on Inquiry Card

Circle 10 on Inquiry Card ——→

Fig. 2

Fig. 2, above. Sonic measurement of finished Hydrospun Nike Hercules nose cones. Thickness of the tapered wall is held to ± .006". Photos and data courtesy of Lycoming Div., Avco Corp., Stratford, Conn.

Cincinnati® Hydroform® machines are built in 8", 12", 19", 23", 26" and 32" sizes; Hydrospin® machines are built in a variety of styles and sizes to meet your production requirements.



Another missile nose gets off the ground via

CINCINNATI Hydroform/Hydrospin!

NIKE HERCULES NOSE CONES are in quantity production at Lycoming (Stratford) Div., Avco Corporation, subcontractor to Douglas Aircraft Co., Inc., Charlotte Div., for these missile components. The success of this work is due to the unique capabilities of Cincinnati Hydroform and Hydrospin machines to form the nose cone to the desired contours and to the degree of precision required.

In the foreground of Fig. 1, below, are shown the five work stages to produce the finished part. "A" is the 17" dia. blank of ½" thick, annealed 6061 aluminum, which is preformed by a Cincinnati Hydroform to the shape shown at "B". Parts "C", "D" and "E" represent the nose cone shape progression through three passes on a Cincinnati Hydrospin. Wall section of the final shape is tapered from .078" at the nose to .125" at the aft end, with wall thickness controlled by the Hydrospin to ± .006". The metal of the finished part is solution heat treated to a T6 condition.

This winning Hydroform-Hydrospin combination is aiding missile and many other component parts manufacturers to produce formerly difficult or impossible sheet metal shapes to specified tolerances . . . while producing major savings in *time, tooling, labor* and *material costs* as well. Look into the many advantages of Hydroforming and Hydrospinning. Call in a Meta-Dynamics Division field engineer for full details.

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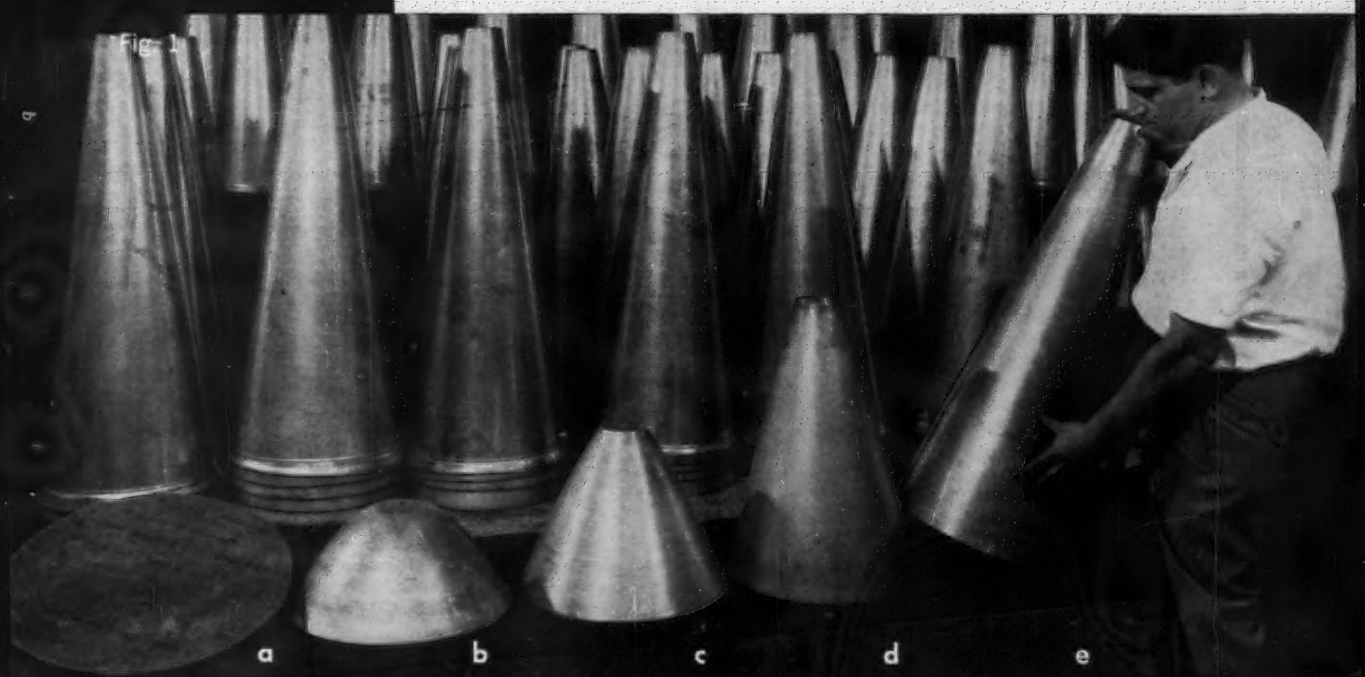
Fig. 1



Portraits of PERFORMANCE

Two rousing tributes to the performance reliability of CECO products are the remarkable records being compiled by the jet airliners pictured above in "gallery display"—the Boeing 707 and Douglas DC-8.

Main fuel pumps for the Pratt & Whitney Aircraft engines powering each were engineered and precision-produced by Chandler Evans. Significantly, during the first exciting year of U.S. commercial jet operation, CECO pumps took part in every single service mile flown by either type of aircraft.

If pictures of missiles and aircraft which are airborne with CECO products actually *were* exhibited in a gallery, the section devoted to pump applications would be an impressive one. In addition, space would have to be set aside for future portraits, since right now . . . at Chandler Evans . . . a number of important pump design and development programs are underway.

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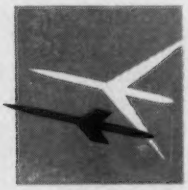
Interesting, informative literature on many CECO products is yours for the asking. Please address your request to Dept. 10.

Data Capsule



SUMMARY OF MANAGEMENT TRENDS AND TECHNICAL DEVELOPMENTS IN THE AEROSPACE INDUSTRIES.

MISSILES AND SPACE VEHICLES

Design

ATLAS-AGENA B vehicle is expected to be ready by December. It will perform missions of the cancelled Vega. Used with Atlas booster, this Lockheed stage could put first synchronized satellite into "stationary" orbit 22,330 miles above the equator. Best launch site would be at, or close to, the equator. Three synchronized satellites could cover 80 per cent of earth's surface in satellite communications system.

MULTI-LAYER SPACE SUIT for Mercury Astronauts required a top research and manufacturing effort. Navy's Air Crew Equipment Lab modified its Mark IV pressure suit. It must protect against capsule depressurization and possible 180°F re-entry temperature, keep body cool, ensure mobility under 5 psi. B. F. Goodrich then used special fabricating process to produce 21 suits. Astronaut wears cotton inner garment. Pressure suit over this has inner layer of neoprene bonded to nylon. Insulating material separates this from aluminized nylon outer coating.

SUBORBITAL TEST SHOTS of Redstones in Project Mercury are scheduled to begin early this Summer, and continue at a rate of one per month. An Astronaut will be rocketed 200 miles from Canaveral in the fifth shot. Test firings of Atlas boosters, carrying animals, are slated to begin before the Redstone program is completed.

BIG JOE MISSION last year gave NASA enough data on capsule separation and ablation heat shield's performance in re-entry. NASA cancelled second shot in this phase of Mercury research. Last two Little Joe shots testing the escape system are scheduled early this year.

NIKE-ZEUS MANAGEMENT is now under Col. John G. Zierdt. He was named deputy director of the Army Rocket and Guided Missile Agency which controls the development program.

HYBRID ROCKET ENGINE (liquid oxidizer and solid fuel) is under development at Reaction Motors Div. of Thiokol Chemical Corp. Thiokol predicts specific impulse values above 300-lb-force-seconds per lb. of mass.

ATLAS INERTIAL GUIDANCE is scheduled for flight-testing this month. It is not quite as accurate as previous General Electric/Burroughs command guidance system. This is a comparatively small loss considering that the inertial system cannot be jammed and allows Atlas to be fired in salvos. System was developed by American Bosch Arma. Both ground and inertial systems operate for only a few minutes. Nose cone then goes to target in a ballistic trajectory.

LIQUID HYDROGEN rocket engine of 150,000 lb thrust will be developed for clustered use in Saturn's second and third stages. Proposals for development contract are expected this month. Fourth and fifth stages use Pratt & Whitney XLR115-P-1 engines of 15,000-20,000 lb thrust.

AIR-LAUNCHED ballistic missile study at Douglas is almost complete.

Development

FIRST MIDAS FLIGHT TEST is scheduled this month, according to the Air Force. This "Missile Defense Alarm System" is to have at least six satellites in polar orbits over 1500 miles high.

NEW BRITISH MISSILE has code name Red Top. Designed by de Havilland, it resembles the Firestreak but is larger. Red Top is reportedly about 15 ft. long.

Production

HUFFORD TRANSRECTOR, 80-ton unit for transporting rocket engines, is now in use at the Brigham City, Utah, facility of Thiokol Chemical Corp. Built by Hufford Div. of The Siegler Corp., El Segundo, Calif., it can handle Minuteman engine units up to 35 ft. long and 80,000 lb in weight.

FIRST PRODUCTION HOUND DOG air-to-surface missile was recently accepted by the Air Force. SAC gets its first squadron of Hound Dogs this summer.

PRODUCTION PROBLEMS still plague the Atlas Mk-3 ablation heat shield. Cure and post-cure are being studied to eliminate low-temp shrinkage problems. Different rates of expansion between heat shield and metal under structure have actually broken the adhesive bond which joins them.

AVCO is seriously looking at nylon cloth as a replacement for Refrasil in Minuteman and Titan ablation nose cones. Reason, easier to produce and lighter.

Procurement

ONE HUNDRED COBRAS, wire-guided 20-lb, anti-tank missiles, have been ordered for tactical evaluation by the Marine Corps. Cobra was developed by Boelkow Entiwicklungen, German missle firm.

AIRCRAFT

Design

AIRCRAFT SPINS have been analyzed by both NASA and the Air Force on 60-deg delta winged aircraft. NASA reported that the method by which a spin is entered may lead to significant differences in spins and recoveries. This could seriously complicate piloting techniques.

THE SWALLOW, one of latest British designs, employs a variable sweep feature. Pod-mounted engines above and below the wings, well out along the span, rotate so thrust is always along the line of flight. A thin, flat, fuselage, which projects well ahead of the wing, contributes some lift. Swallow is designed to cruise at Mach 2.5.

TEST PILOTS have flown aerodynamically unstable jets with automatic longitudinal stabilization systems at subsonic speeds. Normal-acceleration command system and pitch-rate system gave good control. Pitch-damper system gave adequate control. A supersonic-cruising plane might have analogous static longitudinal instability at subsonic speeds.

Development

X-15 FLIGHT PROGRAM enters its final phase soon when first model is delivered to NASA and the Air Force. North American will continue acceptance flight-test program with second model and make first flight on third model. Latter will use Reaction Motors XLR-99 powerplant with 50,000 lb thrust. NASA-Air Force program has steady buildup to eventual 3500 mph and 100-mile altitude.

IMPORTANT CHANGES are taking place in the British aircraft industry. The Hawker Siddeley Group, which builds the Hunter jet, announced plans to take over Blackburn and de Havilland if stockholders approve. Remaining half of the industry was expected to remain individually controlled. However, Vickers-Armstrongs, English Electric and Bristol Aeroplane recently announced their own merger plans.

ANGLO-AMERICAN COOPERATION on a Mach 3 transport is a possibility, according to Peter Mansfield, managing director of Bristol Aircraft. He recently stated that the British aircraft industry has much to offer in research facilities and can produce prototype cheaper than American industry.

Production

FIRST TRACER EARLY-WARNING AIRCRAFT are on duty with the Atlantic and Pacific fleets. Planes carry air search radar.

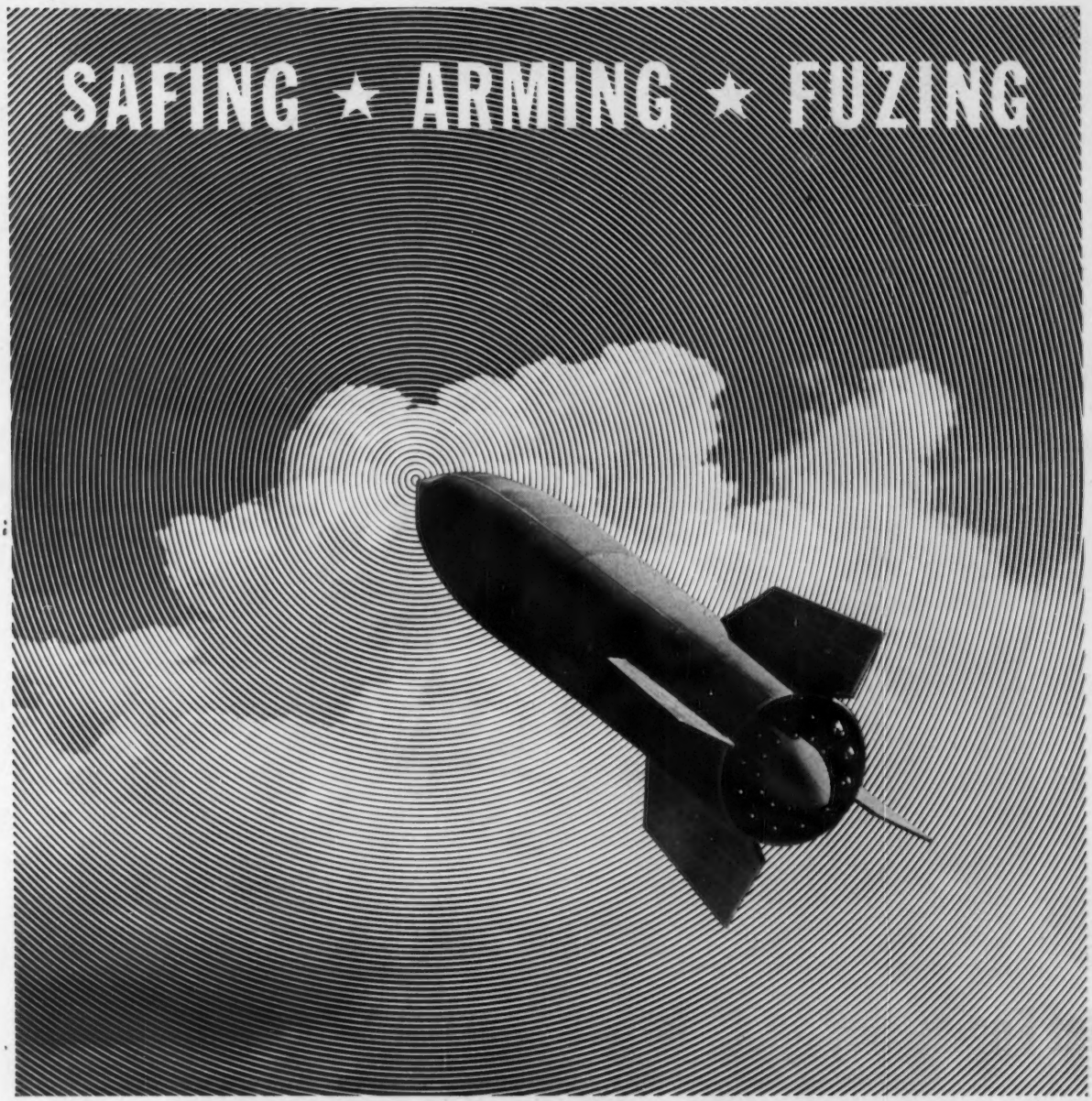
ROLLOUT of Kaman K-16B VTOL aircraft is scheduled later this month.

FIRST CT58-100 commercial turboshaft helicopter engine has been delivered to Sikorsky Aircraft by General Electric's Small Aircraft Engine Dept. Engine is commercial counterpart of the T58-6 developed for the Navy.

Procurement

B-58 ORDERS for this fiscal year were cut from 32 to 20 in Air Force economy move. The Air Force has also cut 30 KC-135 tankers from original order of 96.

SAFING ★ ARMING ★ FUZING



BENDIX RED BANK ANNOUNCES NEW FACILITIES for research, development and production in Safing, Arming, and Fuzing Systems and Components. As systems increase in complexity the need for higher precision in safing, arming, and fuzing grows. To meet this need, Bendix Red Bank Division has created a new department exclusively devoted to design, engineering, and production techniques for these vital systems. ■ This "Special Products Department" is staffed by engineers selected for special abilities in this field. Environmental test equipment and precision tooling enable swift, accurate transition from design to product. Fresh approaches to design and production problems are encouraged by environment conducive to creative thinking. Performance-proved production resources back up new ideas. ■ Since 1941, Bendix Red Bank has grown from a maker of simple electrical devices to a producer of complex electrical and electronic systems. This is added assurance that here your most complex safing, arming, and fuzing problems will receive knowledgeable attention from fundamental analysis through final production.

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Red Bank DIVISION

EATONTOWN, NEW JERSEY

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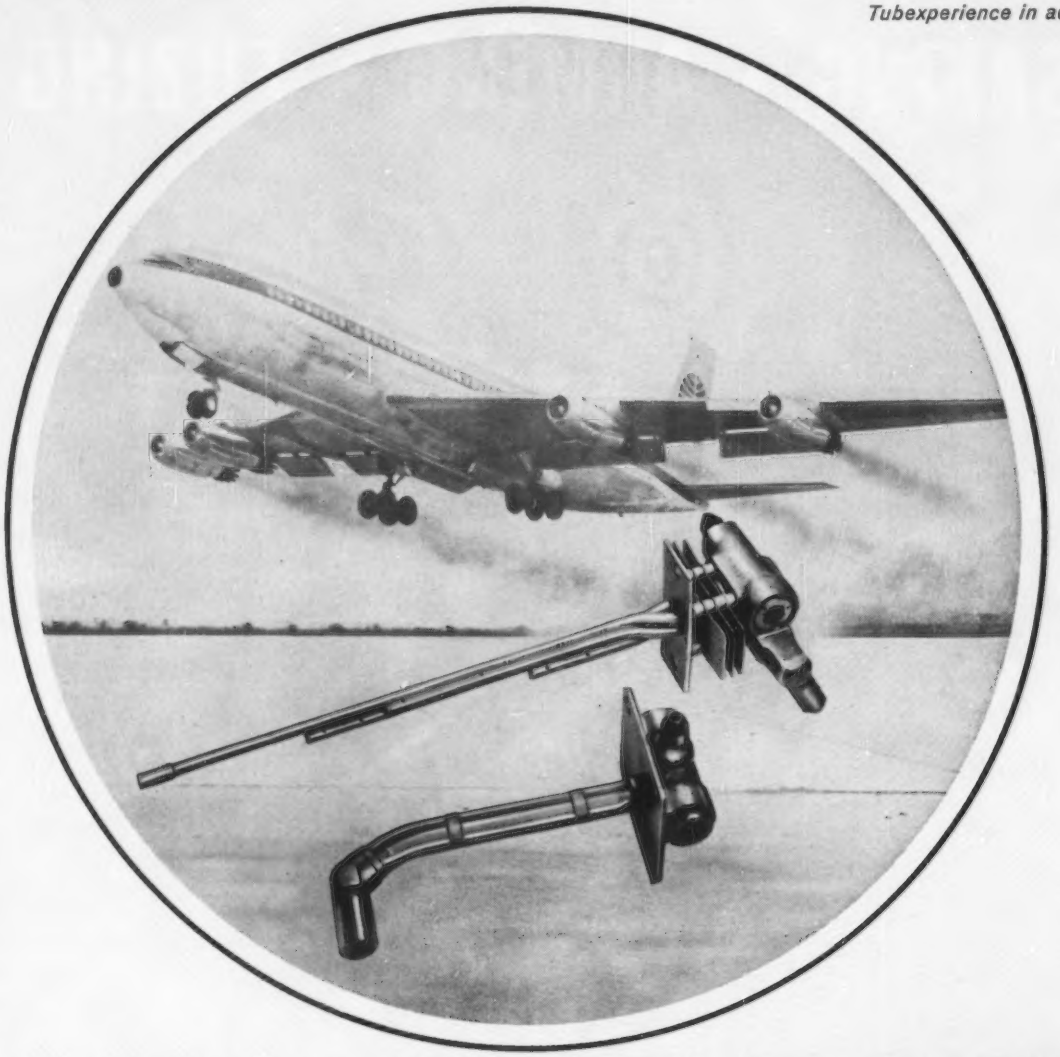
Tubexperience in action



Jet Engine Hot Spots Torture Superior Super Alloy Tubing

Tubing must not take a permanent set or rupture

Temperatures up to 1800°F torture the Superior Super Alloy Tubing used as fuel lines to spray nozzles and as spray bars for afterburners in a current model jet engine. High oxidation resistance and strength at elevated temperatures are a must. But of even greater importance is the ability of the tubing to resist taking a permanent set or rupturing under the high stresses developed in service.

Parker Aircraft Co.'s Engine Accessories Division, Cleveland, with our cooperation, chose the analyses. Service conditions and fabrication requirements limited them to two: N-155,* incl. approx. 21% chromium, 20% nickel, 20% cobalt, balance iron—plus columbium; Haynes No. 25,† incl. approx. 20% chromium, 10% nickel, 15% tungsten, balance cobalt. Both have excellent oxidation resistance, stress rupture characteristics, high strength at elevated temperatures.

N-155 tubing, as produced by Superior, was selected for the fuel lines because it is amenable to bending and shaping without cracking and is easier to braze. It is also used for the spray bars operating in temperatures under 1300°F because it is easier to drill. When higher temperatures are encountered by spray bars, Haynes No. 25 tubing is used.

Superior Super Alloy Tubing, in a wide range of standard and special analyses, in ODs ranging from .012 through 1.125, is available in both Seamless and WELDRAWN® types. Bulletin 70 describes them in detail. Write us for your copy. Superior Tube Company, 2053 Germantown Ave., Norristown, Pa.

*Reg. U.S. Patent Office, Union Carbide Corp.
†Reg. U.S. Patent Office, Haynes Stellite Co.

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The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

Circle 13 on Inquiry Card

Circle 14 on Inquiry Card →

PRIMARY PRESSURE STANDARD

ACCURACY ± 1/50% OF READING (PSID)
RANGE 0.4 TO 250 PSID

- SIX DIGIT DISPLAY
- DIRECT READOUT IN PRESSURE
- PORTABLE OR RACK MOUNTED
- INTEGRAL PRESSURE CONTROL
- ONE DIAL COMPENSATION FOR LATITUDE AND ALTITUDE (SURVEYED)
- WILL ACCOMMODATE ABSOLUTE AND GAUGE PRESSURE WITH SIMILAR ACCURACY

Please discuss your requirements with our engineers

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PASADENA, CALIFORNIA
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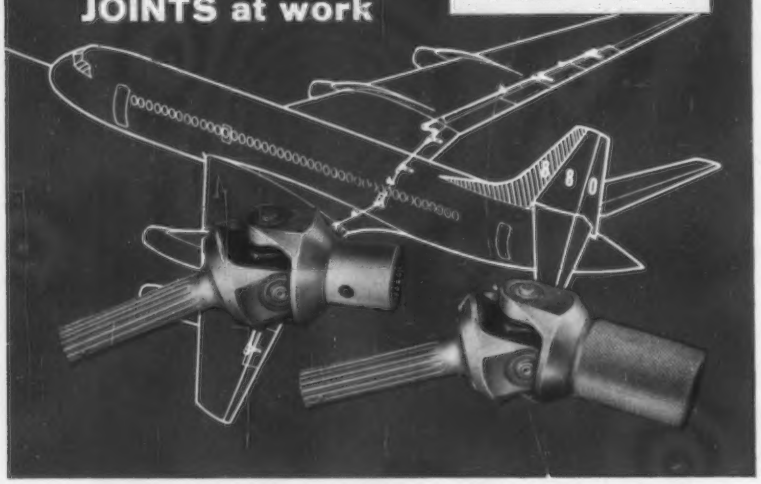
Inside the huge swept wing of the Convair 880 . . .

The 120-foot wing span of the Convair 880 permits landings and take offs from almost any airfield that will accommodate four-engine propeller-driven transports, bringing jet-speed travel to most major world cities.

PHOTO COURTESY CONVAIR DIVISION OF GENERAL DYNAMICS CORPORATION.

APEX UNIVERSAL JOINTS at work



In producing wing flap actuator systems for the Convair 880, Western Gear Corporation selected Apex universal joints. These joints, designed and built to minimize backlash, help provide the instant, precise operation required by jet airliners.

The bearings in each of the Apex universal joints are sealed against abrasive action of sand and dust and have been pre-lubricated for long service life. Male spline, female spline or knurled hub ends are furnished, according to individual application requirements.

Apex manufactures a complete line of aircraft universal joints, standard and special, including the exclusive sealed, lubricant-retaining *covered* universal joint. All Apex aircraft universal joints meet or exceed all requirements of Spec. MIL-J-6193A, Class 1 and Class 2, and Spec. MIL-U-3963A.

SEE OUR CATALOG IN SWEET'S

or write, on your company letterhead please, for Catalog 28 and Universal Joint Data Sheets.

THE APEX MACHINE & TOOL CO.
1030 South Patterson Blvd.
DAYTON 2, OHIO

Phantom view of Apex universal joint with lubricant-retaining cover, an exclusive Apex development. Apex covered joints operate efficiently in wet, dry, corrosive or abrasive atmospheres and in extremes of temperatures.

Your Date Book

January 28-29
Solid Propellants Conference
American Rocket Society
Princeton University, Princeton, N. J.

February 1-5
Technical Committee Meetings
American Society for Testing Materials
Hotel Sherman, Chicago

February 2-4
Fifteenth Annual Reinforced Plastics Division Conference
The Society of the Plastics Industry, Inc.
Edgewater Beach Hotel, Chicago, Ill.

February 3-4
Sixth Annual Midwest Welding Conference
Armour Research Foundation; Chicago Section, American Welding Society
Illinois Tech Chemistry Bldg., Chicago, Ill.

February 16-18
First National Symposium on Nondestructive Testing of Aircraft and Missile Components
Southwest Section, Society for Nondestructive Testing Inc.;
Southwest Research Institute
Hilton Hotel, San Antonio, Texas

February 24-26
Fourth Annual Meeting
Biophysical Society
Sheraton Hotel, Philadelphia, Pa.

March 9-11
Conference on the Mechanical Properties of Engineering Ceramics
North Carolina State College School of Engineering; Office of Ordnance Research, U. S. Army
North Carolina State College, Raleigh, N. C.

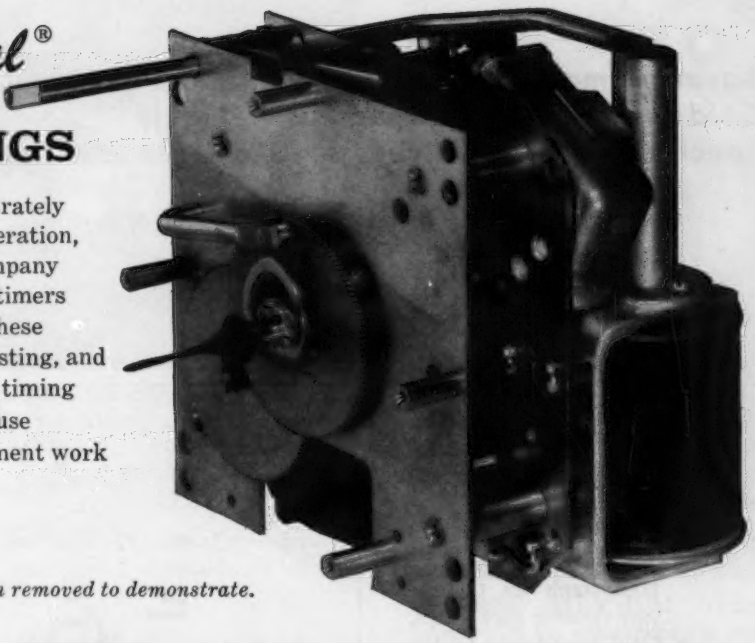
April 4-7
1960 Nuclear Congress
28 sponsoring organizations
New York Coliseum, N. Y., N. Y.

April 6-8
Conference on the Structural Design of Space Vehicles
American Rocket Society
Biltmore Hotel, Santa Barbara, Calif.

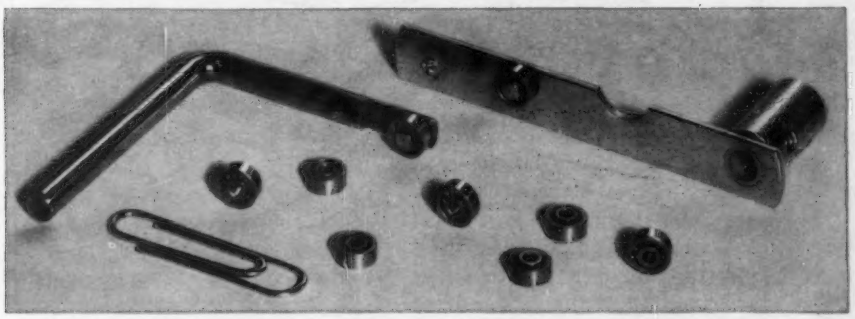
TIME AND PRECISION BEARINGS

HEIM *Unibal*® MINIATURE BALL BEARINGS

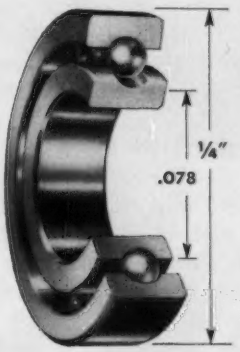
For measuring elapsed time accurately to within .001 of a second per operation, The Standard Electric Time Company manufactures precision electric timers which "split the split second". These timers are used in laboratory, testing, and production work wherever close timing is a requisite. Thousands are in use whenever research and development work must be accurately timed.



Dial and case have been removed to demonstrate.



Heart-shaped cams are attached to both hands of the timer. Miniature Heim Ball Bearings act as cam drivers, or friction-free rollers, to reset the timer after each use.



Unibal Ball Bearings Now Available in Miniature Sizes.

The simplified construction of the Heim Ball Bearing permits its assembly with just the inner and outer races and a full complement of balls. Insertion grooves, retainer rings, and spacers are eliminated.

Shown above are bearings with flush races, bearings with extended inner races for clevis mounting. The two reset arms, as used by Standard, indicate the method of mounting the bearings.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

Save money on your ball bearing requirements with Heim Unibal.

HEIM BEARINGS ARE SOLD BY THE MOST RESPONSIBLE BEARING DISTRIBUTORS IN THE U.S. AND CANADA

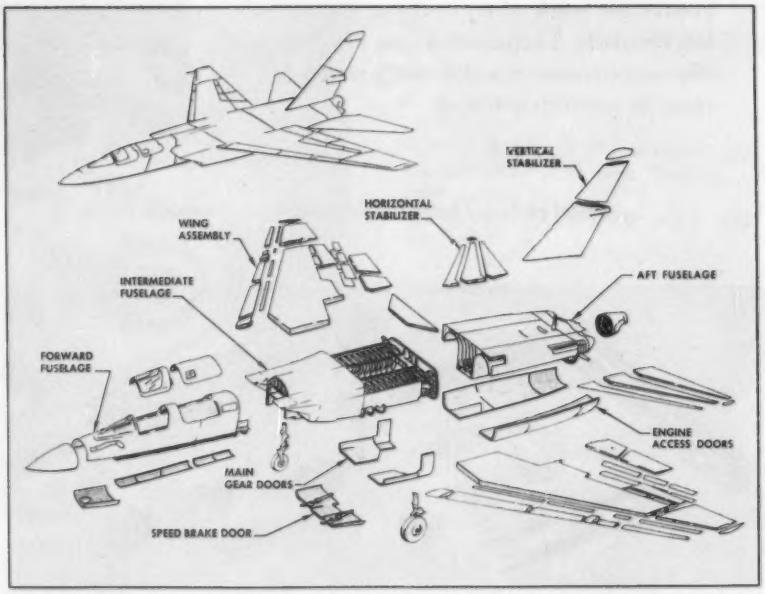
Materials Engineering In The Vigilante

Advances made in use of titanium and high-strength steel;
Gold coat on engine shrouds cuts weight;
Special bonding techniques developed for inlet ramp

A close look at the design of Navy's A3J reveals some clean-cut advances in materials and process engineering. Uses of titanium and high-strength steel stand out. Titanium applications include:

- Adhesively bonded honeycomb for the engine variable inlet ramps.
- Gold-coated sheet for the engine section.
- Forgings for the horizontal stabilizer ribs.
- Extruded shapes for structural members.
- Hot-sized details for general airframe uses.

Hot-work tool steel, and USS STRUX are used as forgings for heavy structural members.



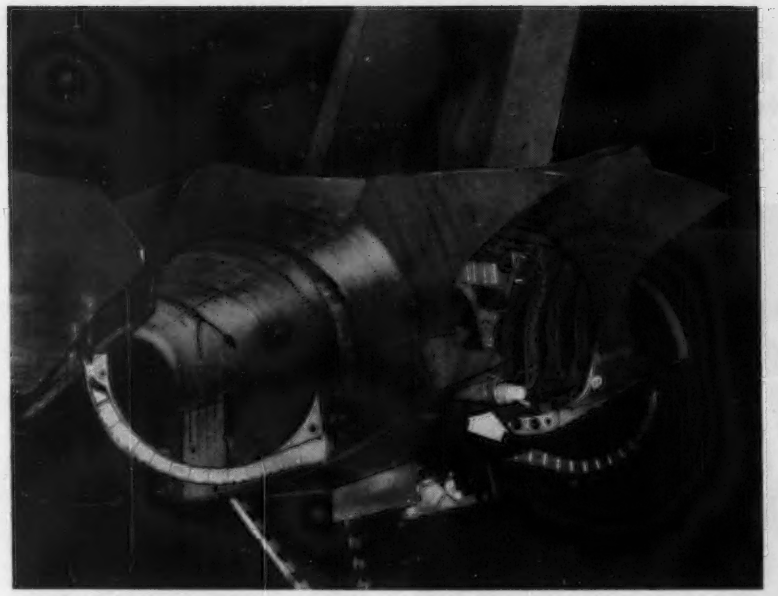
STRUCTURAL DESIGN breakdown shows major assemblies in A3J. Aft section is almost all titanium. High-strength steel forgings are in landing gear and aft control mounts.

Engine Inlet Ramp

Vigilante uses variable inlet-ducts to provide optimum airflow to each of its J-79-GE-2 engines. The movable parts of the ducts are called inlet ramps. Each ramp consists of two, hinged, honeycomb slabs 80 x 25 x 2¾ in. Faces are of either Ti-8Mn or Ti-2Fe-2Cr-2Mo alloy. Core is of 5052-H39 aluminum. Face plates and core are joined by adhesive bonding. No out-of-the-ordinary forming problems were encountered in making the ramps. The adhesive bonding, and two machining steps required special attention.

Titanium face plates have to be taper-milled from 0.090 to 0.045 in. starting with ⅛ in. stock. Warpage resulted when this was first attempted. Warpage was attributed to the inherently low thermal conductivity, high surface reactivity, high yield, and low modulus of titanium. Solution was to mill in one pass, with cutter submerged in a "lake" of coolant. A kind of "movable" dam is builtup around the area being milled. Cutters are changed at first sign of dullness. This meant using about three cutters per face plate.

Milling details are
Taper: 0.045 to 0.090 in. from ⅛-in stock
Cutter: 1¾ to 2 in. end mills
Material: High-speed steel, (AISI M3)



GOLD-COATED engine-shroud is apparent when engine is removed. Aft fuselage is all titanium. Probe (arrow) is for purging air from bomb bay. Forging seen is H-11 tool steel.

LARGEST TITANIUM forging (closed die) yet announced for production application forms horizontal stabilizer rib. Five feet in length, rough forging weighs 170 lb.

Feed: 5 to 20 in./min
Speed: 180 rpm
Coolant: 1 part C_2H_5OH to 3 parts H_2O
Tool Design: No positive rake

Adhesive bonding techniques had to be developed to join the aluminum core to titanium face plates. Bloomingdale's HT-424 adhesive is used. Surface preparation of the titanium is extremely critical. A four-step process is used.

(1) Vapor degrease with trichloroethylene. If care is not taken, this can result in stress-corrosion cracking through chlorine pickup.

(2) Acid pickle. Solution is 25 to 35 percent HNO_3 and 2 to 4 percent HF.

(3) Apply fluoride - phosphate coating developed by Battelle Memorial Institute.

(4) Rinse with hot running water.

Several thousand holes are drilled in each ramp after the bonding operation. The holes have about 0.05-in. diam and are drilled 130 at a time on a milling machine set up. The drills have ¼-in. shanks, even so, one or two drills are lost per pass. High-speed steel drills are used with a water-soluble oil coolant.

Weight-Saving Gold Coat

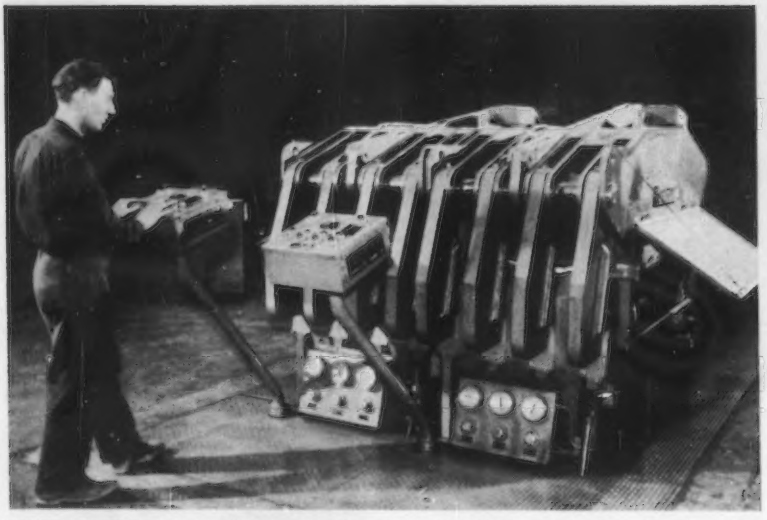
Use of gold-coated titanium engine shrouds is aimed at saving weight. Without the coating, temperatures would rise beyond acceptable limits in the fuselage sections near the engines. Either a much heavier titanium structure, or a heavy steel structure would have to be substituted. Necessity for temperature control in this section of the fuselage is partly magnified by the fact that the bomb load is carried between the two engines.

The gold-coating process does not involve any critical producibility or reliability problems. It is, however, a unique application and is now subject of a North American Aviation (NAA) patent. The process simply involves spraying a gold-resinate liquid on chemically-clean titanium, and baking to hardness. The liquid gold is not unlike that used in the ceramic industry. Final thickness is about 0.001 in. Cost of the treatment is about 1 dollar/sq ft.

continued on next page

ENGINEER CHECKS some of the 85 extruded titanium shapes used in airframe. They are all Ti5Al-2.5Sn alloy. NAA reduced original scrap rate of 85 per cent to 2 per cent during development period.

Titanium forgings in Vigilante retain ductility after hot forging



HOT SIZING (also called creep forming) has done much to solve titanium forming problems. NAA uses two hot-bed presses set up side by side. Pressure is applied in two directions. Setup shown cost $150,000 installed.

PILOT EXAMINES main landing gear strut made of USS STRUX. a new "super steel." Material is 7 per cent stronger per weight unit than other alloys used for this application.

Forged Stabilizer Rib

A Ti-6Al-4V forging in Vigilante's horizontal stabilizer is the largest closed-die titanium forging yet announced. It is about 5 ft long. The forging is made from a 255-lb billet and weighs 170 lb in the rough state. After machining and heat treat it weighs 42 lb, 30 lb less than the 4340 piece it replaces.

Material is selected on the basis of beta-transus temperature. Vendor determines metallographically whether the beta-transus is high enough for this application. The object is to forge at a high temperature without danger of beta grain growth. This would cause a loss of ductility.

Heat-treatment schedule for the forging is:

Solution Treat: 30 min at 1715 ±25°F in air

Quench: Into water, 150°F max, from a drop-bottom furnace; 5 sec max delay

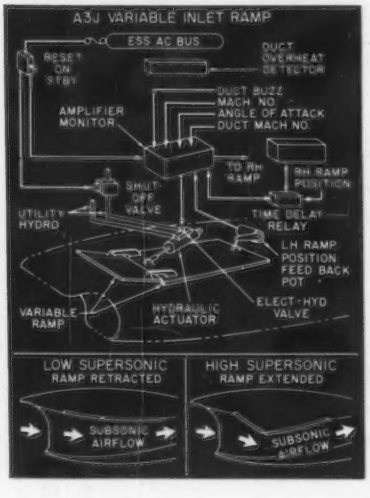
Aging: 4 to 4.5 hr at 1000°F; air cool to room temp.

Minimum properties vary according to section size at time of heat treat. UTS is generally between 160,000 and 140,000 psi. Yield is between 150,000 and 130,000 psi.

✦

HOW THE VARIABLE INLET WORKS

Inlet duct area to each of Vigilante's engines is varied by a hydraulically-operated ramp. Ramp fits flat along the top inner surface of the inlet duct except in supersonic flight. It consists of a fixed section and a modulated section. The two are hinged. Ramp is extended into duct by an hydraulic actuating cylinder sequenced by an electrically-controlled servo. The angle of the modulated second ramp, with respect to the fuselage reference plane, is varied as a function of free-stream Mach number.



A REPRINT

of this article can be obtained by writing on company letterhead to The Editor, AIRCRAFT & MISSILES Chestnut & 56th Sts., Phila. 39, Pa.

A Service Message from MAGNAFLUX *(Advertisement)*

"Just a Little Old Crack"

A crack too small to be seen even with a microscope can stop a countdown —or a missile in flight—or cause failure of ground handling or servicing equipment.

Yet out of a vast accumulated experience, metallurgists now generally agree that cracks or similar defects open to the surface or immediately beneath it are the cause of most localized high stresses and failures of parts under high loads.

Most of them also believe—and put into practice—the fact that preventing failures is very often just a matter of finding cracks . . . that there are many test systems available . . . but that no single test is best for *all* needs.

Only the most careful evaluation—impartially undertaken—permits each test system to be used to its fullest potential.

We suggest that in the missiles and spacecraft program such an evaluation can help to achieve faster production schedules, more effective testing and more "right starts" in design development.

In this race the penalties of failure may be enormous. To you we pledge our fullest cooperation, and will welcome yours.

Meanwhile, in your preliminary thinking, the following listing may be helpful, showing some of the test systems available to you.

X-Ray

One of the most valuable tools, especially for finding sub-surface defects. May be used on practically any material. Permits permanent records for future reference or immediate interpretation. Is relatively slow. May not always find cracks or leaks.

Magnetic Particle

Uses controlled magnetic leakage fields to find all cracks, porosity or other defects at the surface or reasonably close to it. By far the most common crack-finder for magnetic metals used in critical service. Will find some defects in weldments that X-ray may overlook. Marks defects right on the part. Simple procedures enable permanent records. Black light and fluorescent materials speed up testing. May not find very deep seated defects, and requires knowledge of many ways and means of magnetizing complex shapes.

Fluorescent Penetrant

Most sensitive method, uses capillarity to find cracks and other defects open to the surface in nonmagnetic metals, and most other solid, nonporous materials. Recent developments have increased sensitivity—will now find some defects no other method will detect. Readily tests complex shapes or high volumes. Offers near-absolute reliability in leak tests. Special formulae may be used safely on LOX systems. Speed governed only by requirements, but reliable results require engineered test set-up and control.

Dye Penetrant

Dependable test on moderately "clean" or medium to large size defects (which may still be invisible). Original cost very low. May be fully portable, in spray can kits. Can be used on any metal, most other materials. Less sensitive than fluorescent penetrant tests.

Ultrasonic Testing, Resonant

Especially useful for determining thickness measurements from one side only—or finding lack of bond in laminates. Available in both oscilliscope and portable direct reading instruments.

Eddy Current Testing

Developed by Institute Dr. Foerster, Germany, for nondestructive testing. Evaluates effect of conductive materials on eddy currents induced within them. New uses are being found almost daily. Many properties and defects can be evaluated, including hardness, conductivity, alloy composition, chemical purity, cracks, heat treatment conditions or heat affected zones. Instruments for testing magnetic or nonmagnetic metals. Operation may be automated, when desired.

Brittle Coating Stress Analysis

Determines stress concentration and measures values in simple or complex shapes, in static or dynamic testing, and over the entire part. Parts can be immersed in oil or tested at temperatures to 600° F. with newest coatings.

Magnaflux Corporation engineers and manufactures most of the nondesructive test systems mentioned here. These —and numerous others—are available to you through Magnaflux. Our experience is at your disposal—through Magnaflux Nondestructive Testing Engineers who are recognized consultants in their fields, or through technical literature and reports. Write us your questions—or tell us your needs. If we haven't the answer, we'll try to find it for you or will refer you to others who have the answer.

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SPOTCHECK
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ZYGLO
Fluorescent Penetrant Testing

SONIZON
Resonant Ultrasonic Testing

STRESSCOAT
Brittle Coating Stress Analysis

Also Other Test Systems for Most Materials

Commercial and Field Inspection Service, including all Magnaflux Corporation Test Systems, and several others.

Circle 17 on Inquiry Card

How Navy Will Monitor Polaris Underwater Firing

Integrated ship-shore-submarine complex planned; Electronic system in submarine uses modular design; Special cameras provide underwater film record

by Philip Geddes

Collecting data from a ballistic-missile test firing is a monumental task. Put the missile under water in a submarine and the task is further magnified.

Land, Sea and Under Sea

Test and evaluation instrument systems provided by Interstate Electronics Corp. for launch evaluation of the Polaris Fleet Ballistic Missile (FBM) weapon system are in three separate locations:

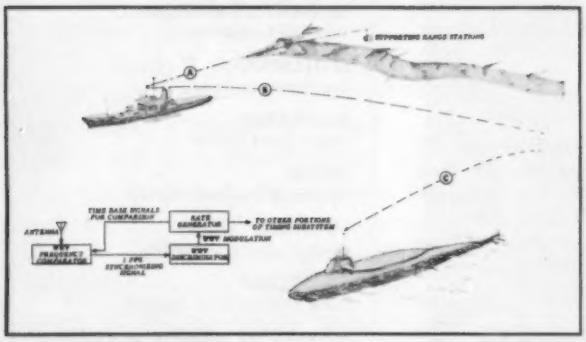
- Shore, launch site.
- Support instrumentation ship.
- Submarine.

Each functions as a separate system, integrated by a firing-range communications network. Overall system provides a complete record of a missile test firing for later evaluation.

Range-site instruments are installed at the Atlantic Missile Range (AMR). Interstate studied requirements of the Navy complex to be installed at Cape Canaveral, and provided a complete telemetry system and a launch complex environmental measuring system for Polaris project. Additional equipment was also installed for inspection and reduction of data.

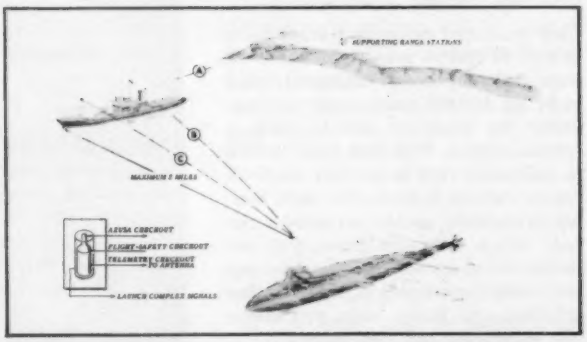
Sea firings of Polaris will take place initially from instrumentation ship, U. S. S. Observation Island. When launchings take place on the ship, the Atlantic Missile Range supplements the operation by providing range safety, and flight telemetry recording facilities. Later, when submarine firings begin, the U. S. S. Observation Island will act as a support ship, and begin coverage as the missile breaks from the

PRELAUNCH TIMING CORRELATION, SUB SURFACED

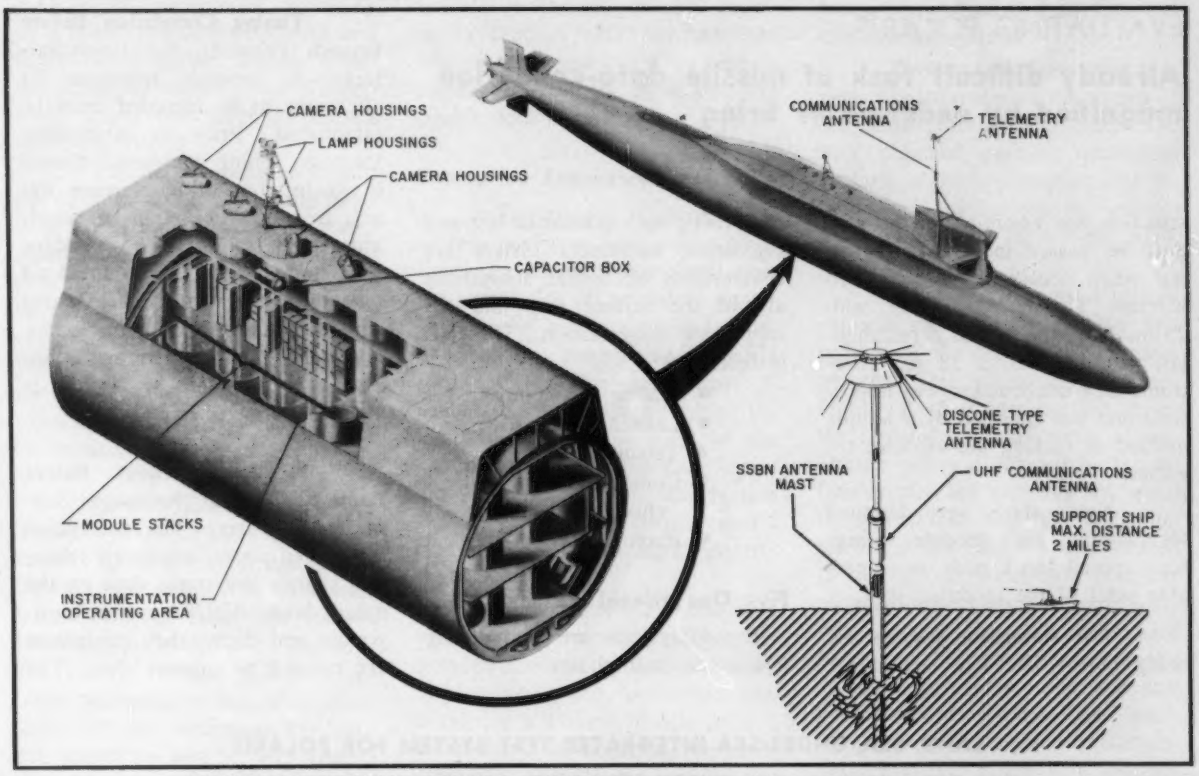


(A) Range Coded Timing (B) WWV Radio Timing Signal Shore-to-Support Ship (C) WWV Radio Timing Signal Shore-to-Submarine. U. S. BuStand Radio Used.

PRELAUNCH MISSILE CHECKOUT, SUB SUBMERGED



(A) Communications, Supporting Range Station-to-Ship (B) Telemetry Checkout Signal (C) Communications Submarine-to-Support Ship.



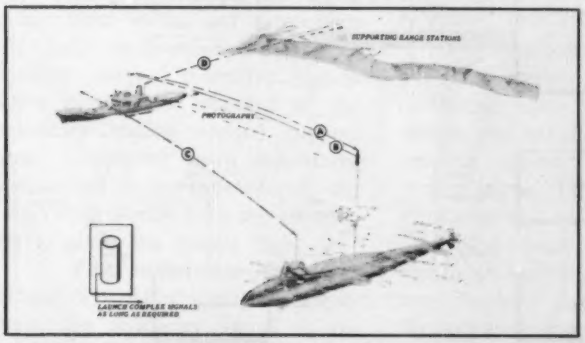
FLEET BALLISTIC MISSILE (FBM), Polaris, launching evaluation system is shown aboard submarine. Electronics are constructed in modules to speed installation and removal. Cameras monitor initial stages of under-water launch. Antennas relay data to ship and shore stations.

surface. The ship will anchor within two miles of the submarine. As the missile gains altitude, shore installations will assume primary monitoring role; shipboard system will remain functional to provide secondary coverage and insure data continuity. Photographic apparatus and television are included in shipborne equipment.

Most fascinating single phase of Polaris instrumentation program is in the submarine. All test and evaluation equipment installed in sub had to be designed for easy access and removal. The system is removed upon completion of tests, for refit into another sub.

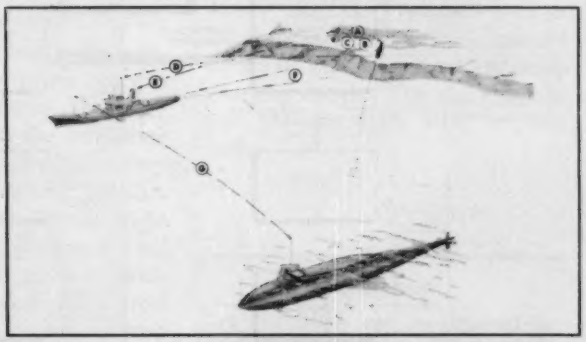
Space is limited in the sub to an area of 5 x 29 ft, with six feet of headroom. Modular con-

POSTLAUNCH, INITIAL AIR TRAJECTORY



(A) Flight Safety Capability (B) Telemetry Signals (C) Communications, Support Ship To SSBN (D) Communications, Ship To Shore.

POST INITIAL AIR TRAJECTORY



(A) AZUSA, Other Radar (B) Flight Safety (C) Telemetry (D) Telemetry (E) Communications, Ship-to-Shore (F) Photography (G) Communications.

Already difficult task of missile data-collection magnified by underwater firing

struction was essential, as the gear must be passed into the sub (and out when necessary) through two hatches. The first is circular, with 25-in. diam; the second is rectangular, measuring 20 x 38 in. Electronic-rack construction was impossible and was replaced by a unique method of locking the modules together.

Nylon slings were designed for handling each module. Slings have special shock pads on vulnerable sides of the modules.

Two submarine systems are being built. The five subsystems comprising each submarine test and evaluation instrument system are counterparts of similar subsystems aboard the surface ship and the supporting range station. The subsystems are:

- Timing and control
- Launch complex.
- Telemetry.
- Communications and checkout.
- Photographic.

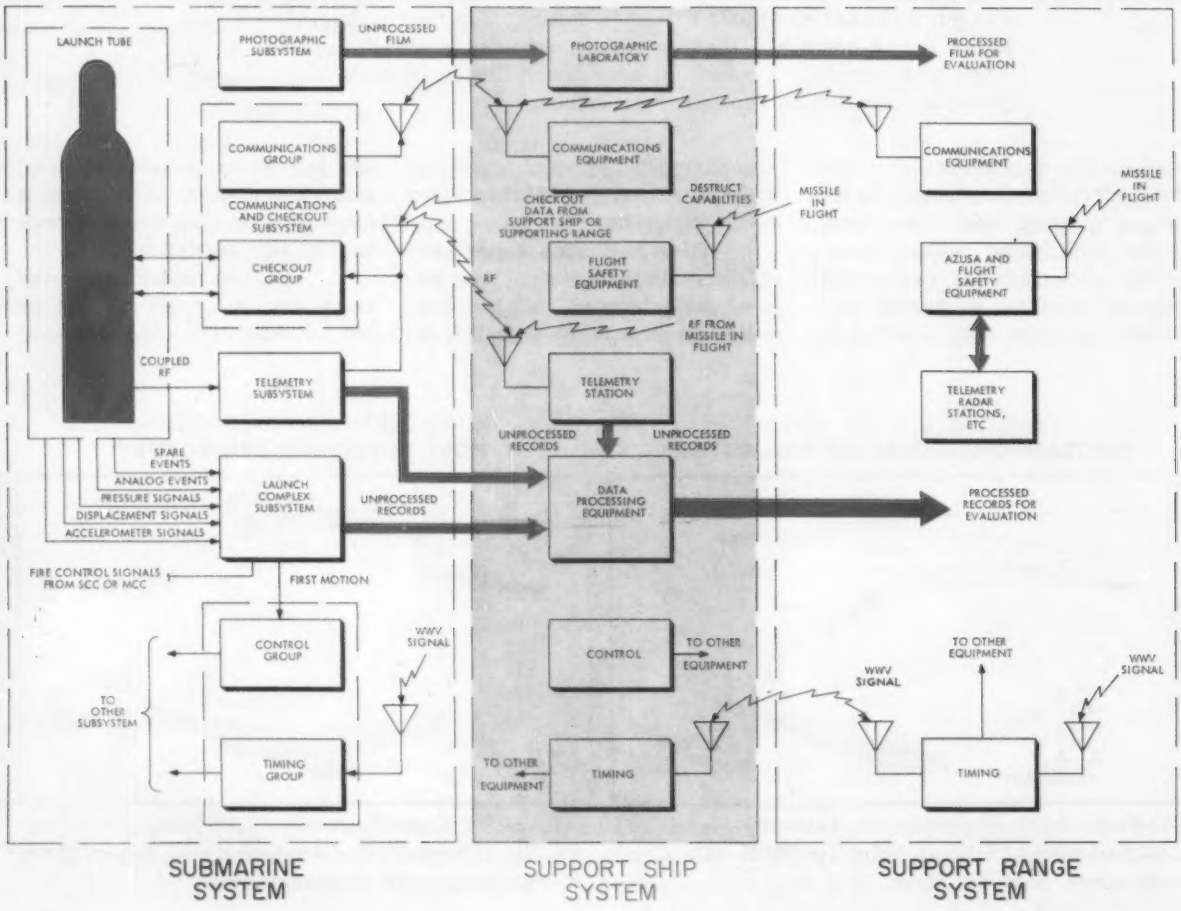
Five Operational Phases

The subsystems are used during five operational phases:

Timing Correlation Before Launch (Phase I). Submarine Surfaced—A common reference for all events to be recorded must be established. Prior to submerging for tests, timing equipment aboard is synchronized with reference signals from U. S. Bureau of Standards radio station, WWV, and/or with timing signals from the land range-timing system. Other timing equipment aboard, supporting mobile range-data gathering stations such as picket ships or aircraft, is also synchronized.

Missile Checkout Before Launch (Phase II). Submarine Submerged — During the pre-launch submerged phase, missile r-f telemetry signals and status data on the missile-borne AZUSA system transponder and flight-safety equipment are relayed to support ship. The

LAND, SEA, UNDER-SEA INTEGRATED TEST SYSTEM FOR POLARIS



AZUSA system consists essentially of a missile-borne transponder and a ground computer. System determines missile velocity and position from which the point of impact can be predicted.

Telemetry subsystem aboard the submarine checks out and monitors missile-borne telemetry transmitters until first motion occurs. It then provides direct re-transmission of missile r-f telemetry signals to support ship for calibration purposes; support ship records telemetry signals. During this phase, various launch-complex functions may be monitored and recorded.

Launch and Underwater Trajectory (Phase III) (not illustrated). During launch and ascent through sea water, the submarine launch-complex subsystem records functions associated with the missile launch. These functions include pressures, strains, shaft positions, voltages, vibrations, mechanical actuations and so on. During the underwater trajectory, the submarine photographic subsystem photographs the missile emerging from the launch tube and ascent to the surface. Photographic coverage is designed for viewing all possible missile paths. Cameras and lights are automatically started and synchronized as missile is launched.

Post Launch (Phase IV). Initial Air Trajectory—After launch and during initial air trajectory, submarine-borne equipment records launch-complex functions as long as required. Camera systems aboard support ship photograph the missile rising from water, and subsequent air flight until missile is out of viewing range. Telemetry signals from missile are recorded at the telemetry station aboard support ship. Depending upon procedures established at the time of test, the support ship may have the capability to abort the missile flight.

Post Initial Air Trajectory (Phase V). After initial air trajectory, the telemetry signal is recorded at the support ship as long as reception is possible. Supporting range stations receive and record missile signals, and provide flight safety check. After test, all submarine test records can be sent to the support ship for processing and "quick look" evaluation.

Submarine Subsystems

Timing and Control Subsystem performs four major functions: 1. generates correlated timing signals for all recording equipment in the instrumentation system; 2. provides programmed control for the recording equipment; 3. provides facilities for informing the instrumentation supervisor of the status of all subsystems, and 4. provides countdown time information for the system, the missile control center, and the ship's control center.

Launch Complex Subsystem measures and records physical phenomena such as strains, pressures, displacements, etc., associated with launching a Polaris missile from a submarine. In addition, the subsystem records the time of the occurrence of events taking place during the launching. Audio commentaries such as countdown and fire-control-commands are also recorded. This subsystem is designed to provide sufficient flexibility for monitoring many combinations of environmental conditions during a missile launching operation.

Telemetry Subsystem performs two major functions. The first is to relay r-f telemetry signals from the missile to the support ship. This enables the support ship to monitor the entire pre-launch procedure. The second function is to record these pre-launch signals.

Communications and Checkout Subsystem provides certain communications within the submarine and between the submarine and the support facility. Checkout provisions are for testing AZUSA transponders, missile borne flight safety and telemetry equipment. All signals to and from the submarine are received and transmitted through an antenna system mounted on a tall mast located on the sail of the submarine. Other communications possibilities such as cables and buoys were discarded in favor of this antenna system.

Photographic Subsystem provides film coverage of the ascent of the missile through the water. The data obtained permits qualitative analysis of such phenomena as attitude and cavitation, as well as some indications of missile pitch, yaw and roll.

Four 16mm motion picture cameras record action in the first portion of the ascent at 90 frames per sec. Two similar cameras, operating at 45 frames per sec, cover the remainder of the water ascent. Shutter pulses developed by the 90 frames per sec cameras are used to synchronize the photo lighting set. The six cameras are located in two of four water-tight housings mounted externally on four firing tube hatches on the submarine hatch deck. From this position the cameras can survey one test and evaluation firing tube. The cameras must be transferred to the second set of two water-tight housings in order to survey the second test and evaluation firing tube.

Lighting for the first portion of the under water ascent is provided by five high intensity flash lamps mounted on a tower on the hatch deck. Photographs taken underwater are limited in recording detail due to the smearing effect caused by the motion of particles suspended in the water. This smearing is minimized by using high intensity, short duration flashes from the lamps. The bottom lamp flashes 90 times per sec and the top four each flash 45 times per sec. 450 v, 60 cps, 3 phase power is supplied by the ship and converted to 2300 VDC for the flash lamp charging circuit. The charging circuit provides 4000 VDC to each lamp.

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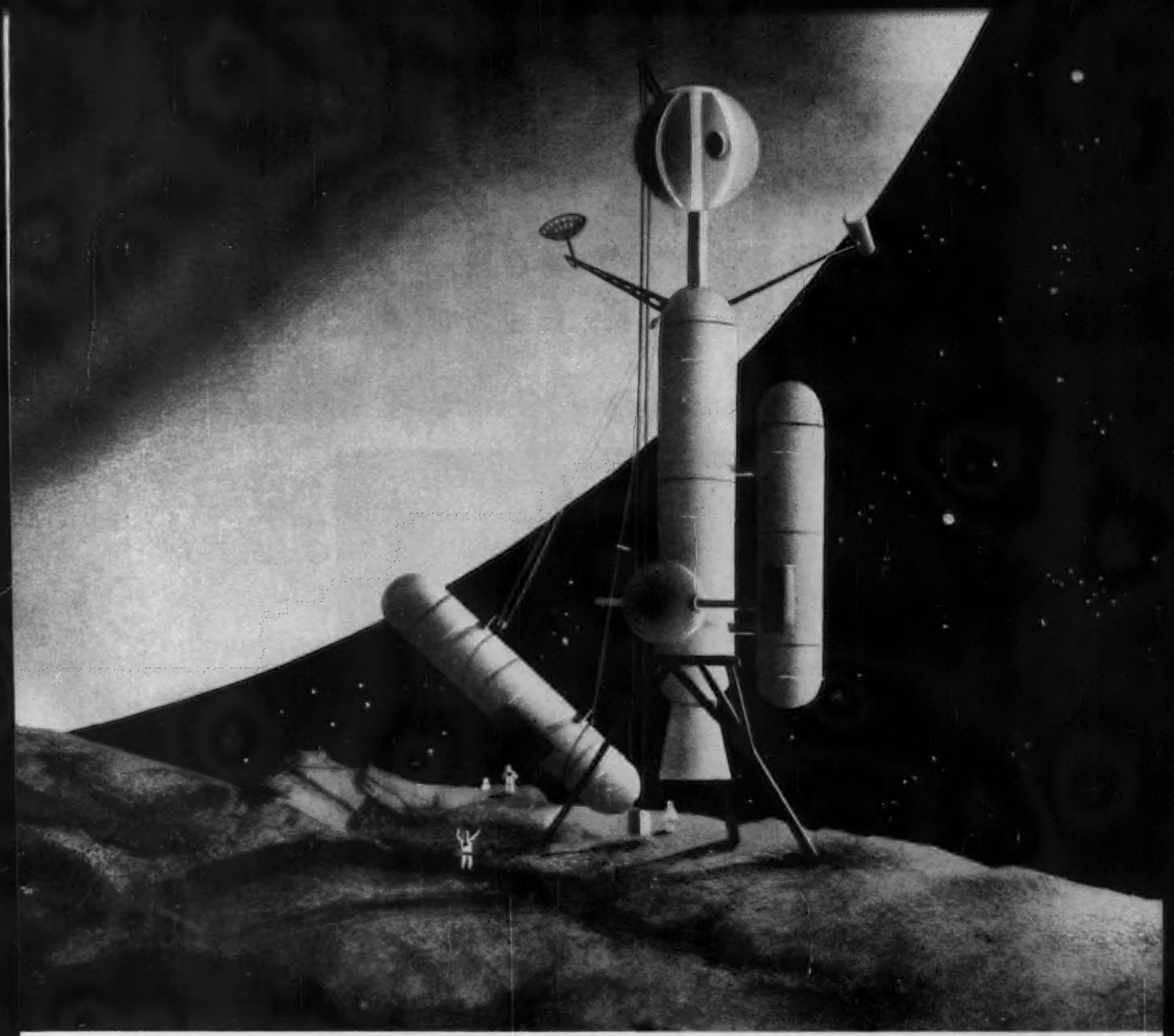
In our engineering department, current projects include: specialized inflatable vehicles and structures, airborne early warning systems, micro wave radar test equipment,



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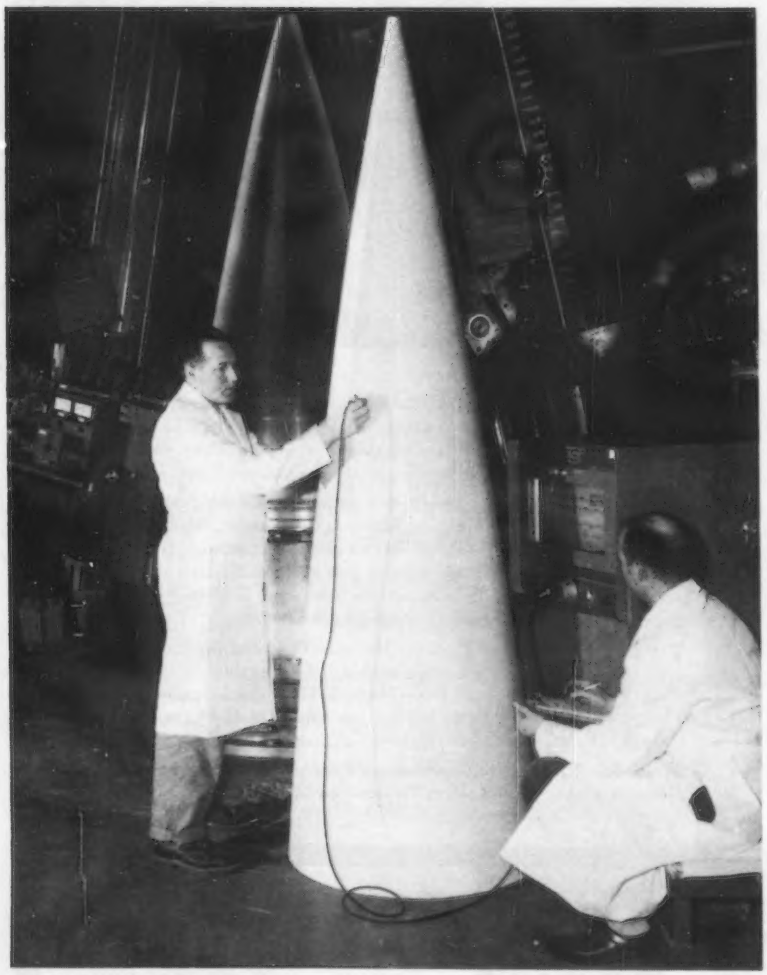
Ultrasonics Cut Nose-Cone Gaging Time

Thickness of filament-wound and wet-layup plastic shapes checked to accuracy of ±0.001 in. Inspection time cut from week to less than a day

by Don Paisley,
Brunswick-Balke-Collender Co.



FILAMENT WOUND Bomarc nose cone is checked to ±0.001-in. thickness tolerance with ultrasonic resonance gage. Readings are taken directly in inches.

Ultrasonic thickness gaging is being extended to filament-wound plastic nose cones by Brunswick-Balke-Collender at Marion, Va. Tolerances of ±0.001 in. are aimed at. The gaging device in use is Branson Instrument Inc.'s Vidigage.

The ultrasonic resonant gaging technique is already a proven time and money saver in checking nose cones fabricated by hand layup. Cones are often made thicker than required, and hand worked to final dimension with repeated "cut and try" measurements. End-item gaging time has been cut from a week to less than a day in checking some 4000 points on the B-58 radome. Tolerance in this case is ±0.005 in. Another shape where the ultrasonic gaging technique has been used is a huge submarine-radome — thickness tolerance ±0.002 in.

Critical wall thickness is not achieved at the expense of other measurements. The finished shape must also fit a master contour almost exactly.

Considering that some nose cones are up to 12 ft long, with an aft diam of up to 6 ft, the problem of holding such precise tolerances seems near impossible. Getting accurate measurements used to be a major problem. The size of the relatively thin part itself causes flexing,

WATER IS APPLIED to area which transducer touches. This assures good coupling of sound waves emitted by transducer. Crayon marks show close proximity of check points.

TWO MAN TEAM is used for quick accurate recording. On cones made by wet layup, thickness is measured directly on layup tool. Infrared lamps are used in curing.

and temperature variations are often enough to cause changes in readings greater than permissible tolerances.

Measuring techniques tried and abandoned were: gamma ray devices, air gages, and standard deep-throated calipers or banks of dial indicators. Dial indicators gave best results, but were very tricky to handle, took a long time to set up, and—worst drawback of all—a special fixture had to be designed and built for each different nose cone. With measurements to be taken on 2-in. centers around the periphery and along the axis, it is easy to understand why it sometimes took up to a week to gage a single part completely. Where only a few nose cones were to be built, as in prototype work, the cost of gaging was often higher than the cost of making the part.

Measures From One Side

The advantages of an ultrasonic reasonance gage that can measure from one side, with accuracy of a conventional micrometer, are obvious:

(1) Thickness of cone can be measured while it is still on the mandrel, or over the mold. Being thus supported, there is no flexing or deviation in actual shape, and there is little chance of handling damage. (2) Because thicknesses are determined before the cone is removed, alterations can be made and rechecked immediately. (3) Careful repositioning in a measuring fixture each time the nose cone is sanded down or built up is completely eliminated. (4) Length, diameter, or variable contours of part do not affect the operation of the resonance gage. Cones a hundred feet long, could be measured at the very tip just as easily as at the aft end. There is no need to get inside.

Other Advantages

Other benefits of ultrasonic measuring are:

Instrument is portable. Mounted on a wheeled dolly, it may be moved where needed or, when necessary, two men can carry it.

Gage is reliable. Its accuracy is guaranteed to within 1.0 per cent of actual thickness over a wide scale range. If a fairly narrow range is used, measuring to within 0.001 in. is routinely possible. Usual thicknesses range from 0.020 to 0.500 in. at Brunswick. Several times daily the gage is quickly recalibrated on a piece of plastic having the same composition as that of the nose cones being built. Checks with micrometers have consistently confirmed the instrument's reliability. *Text continues on next page*

Wrong parting agent can foul accuracy of ultrasonic instrument

Measuring is fast. As soon as the transducer of the Vidigage is applied to the outer surface of a nose cone or radome, two or more traces appear on the cathode ray screen. A calibrated scale gives direct thickness readings in inches. There is no need for calculations of any sort.

Parting Agent Important

In filament winding or hand lay up, the choice of parting compound is important to resonance gaging.

If the parting compound forms too good a couple between the plastic part and the mold or mandrel, getting a clear scope reading is difficult. The sound waves are not reflected from the interface between plastic and steel, but penetrate into the metal. The result will be either a very indistinct reading or no reading at all.

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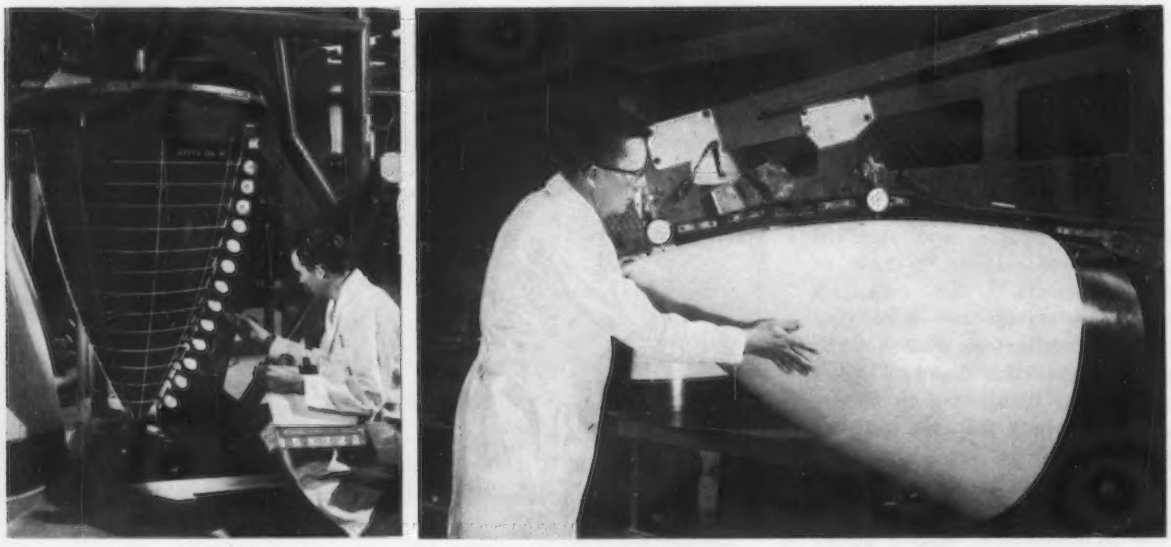


CONTOUR IS ALSO CRITICAL, and several dial gages are used to assure accuracy. Left technician checks master contour with a series of surface gages. Right, finished shape is checked for contour on master tool with same type gages.

How Ultrasonic Resonance Gages Work

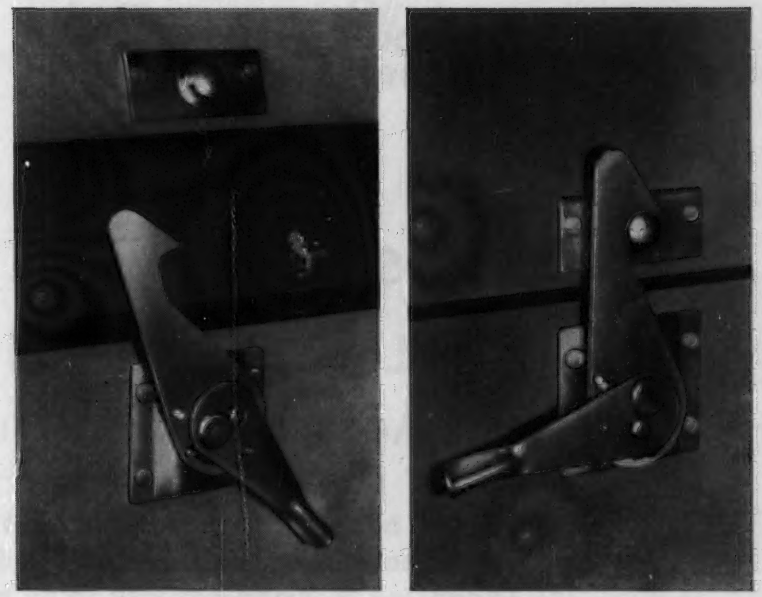
Principle of an ultrasonic resonance gage is quite simple. A continuously varying frequency—ranging from 0.5 to 25 mc—is generated by the electronic circuitry of the gage and changed into mechanical vibrations by the transducer. When these vibrations are sent into a metal or plastic, they bounce back from the far side. Picked up by the same transducer, they are introduced back into the circuit for amplification.

When a returning wave is in resonance with an outgoing signal, this particular frequency causes a heavier load on the circuit. The resulting increase in plate current shows up as one or more traces on the cathode ray tube. This is very similar to the c-r-t used in a television set. Each trace represents either a fundamental resonant frequency or a harmonic.

Because the resonant frequency of a sound wave in a given material varies inversely with the thickness of the material, an indication of resonance can be directly converted into thickness. In the Vidigage, this is accomplished by placing a calibrated scale in front of the cathode-ray tube, to make thickness determinations directly. Scales are available, to handle a variety of metals, plastics and other materials, in a number of ranges. Highest accuracy is achieved by keeping the scale range as small as possible.

WHAT HOOK-LOCK IS

HOOK-LOCK is a springless, positive-locking latching device which is ideally suited for use on rigidly specified military transit cases as well as less expensive commercial containers. It provides high closing pressure and tremendous load-carrying capacity...is impact and shock-proof. HOOK-LOCK is so designed that it lies flat against the mounting surface whether in open or closed position. Since operation is parallel to mounting surface, no space for operating clearance is required.



HOOK-LOCK lies flat against mounting surface, open or closed.

New—HOOK-LOCK container latch...It's flat!

FEATURES

- Shock-proof—solid construction...withstands high impact blows *directly on the fastener.*
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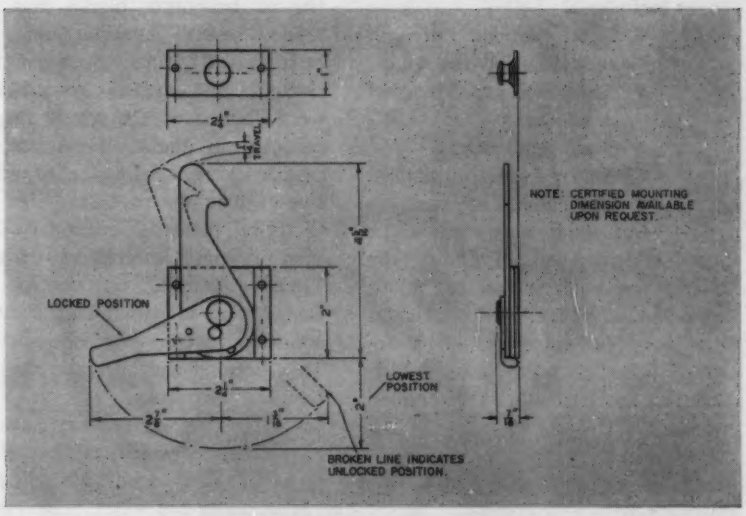
- Tensile load capacity: 750 lb.
- Compact—lies flat open or closed. Extends just 7/16" from container surface at thickest point.
- Positive-locking and springless. Unaffected by arctic temperatures.
- No operating clearance required, because hook and lever move parallel to mounting surface.


LOCKED POSITION
LOWEST POSITION
NOTE: CERTIFIED MOUNTING DIMENSION AVAILABLE UPON REQUEST.
BROKEN LINE INDICATES UNLOCKED POSITION.

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AN AIRCRAFT & MISSILES SPECIAL STAFF REPORT

Adhesives—

Still Lots of Potential For Aerospace Structures

"Poor" heat-resistance could hurt; But, inherent advantages of bonded structures is causing frenzied activity to up heat range

Structural adhesive bonding is now an intricate science. Advantages gained by bonding parts together can insure adhesives a future in aerospace vehicles. These advantages include:

- Good fatigue strength and vibration resistance.
- Resistance to thermal shock.
- Good resiliency.
- High galvanic insulation.
- Low fabrication cost.

But, with each missile or satellite firing, we are finding the near space environment to be increasingly complex. New challenges are being presented for all structural materials. Problems which seem to apply to adhesively bonded joints for space-return vehicles are:

- High vacuum, which could cause entrapped air to explode a joint.
- Ionized and dissociated gases, which will cause bond deterioration.
- High temperatures caused by natural and induced environments. Temperature resistance of adhesives should be much better in space, where no oxygen exists.
- Cosmic radiation, which may deteriorate the exposed edges of bonds. The nature of a bonded joint protects the joined area.

First real breakthrough in adhesive bonding came from research in the VTOL field. Service life of helicopter blades was extended several hundred times by bonding all joints. Spot welded, riveted, and bolted rotor-blades would not stand the severe fatigue induced in flight. The damping properties and resilience of adhesives solved the problem. This led to trying bonds in secondary and then primary aircraft structures. Then, with the introduction of honeycomb-sandwich-construction, adhesives were over the hump. This became the accepted way of building airframes.

Several adhesively assembled Explorer satellites have been launched into orbit. No data is available on the exact behavior of bonds; it was not a test objective. Recently, Republic Aviation has made sample rocket motor cases by adhesive bonding.

Classes of Adhesives

There are many ways of classifying adhesives now in use. No one system suits all purposes. To classify structural adhesives as thermoplastics, thermosetting, or combined thermoplastic—thermosetting is usually adequate. The last two are most widely used in the aerospace industries. They are also the most expensive.

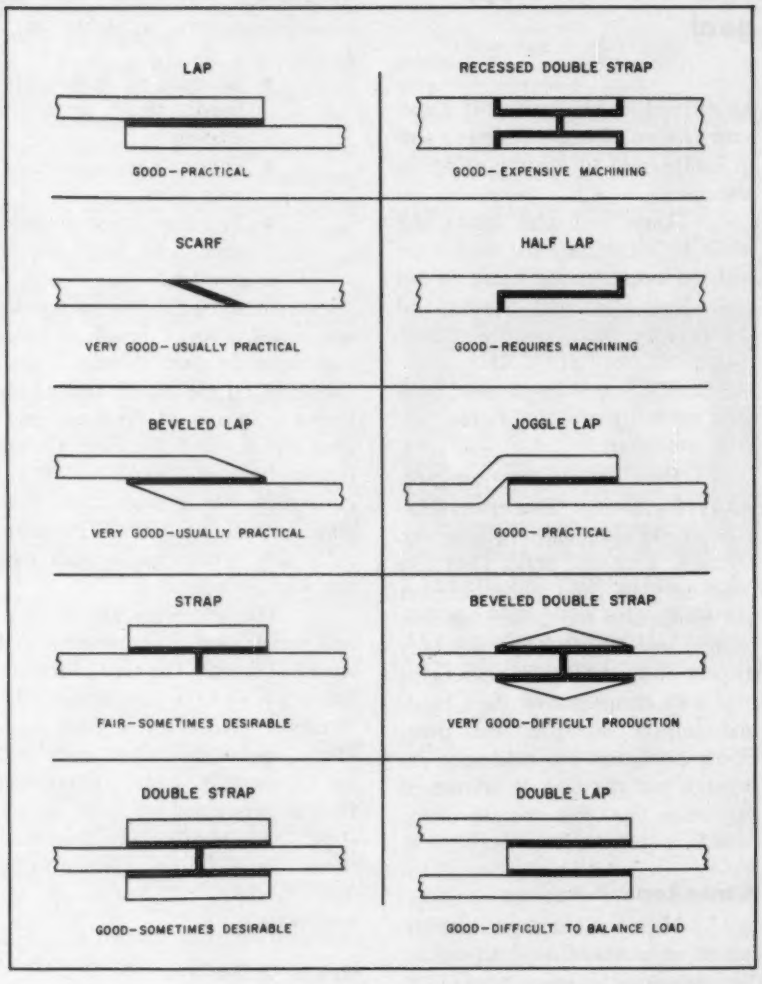
Chemically, thermosetting adhesives can be classed as epoxy, epoxy - phenolic, phenolic - vinyl, phenolic-nitrile, phenolic-neoprene, and phenolic-polyamide. Even with this breakdown the variety of molecules is hard to list. New blends appear almost daily. Molecules are being tailored to specific applications.

The thermoplastic—thermosetting breeds are basically modified vinyl-phenolic resins. Room temperature shear strength of most of these adhesives ranges to 8000 psi.

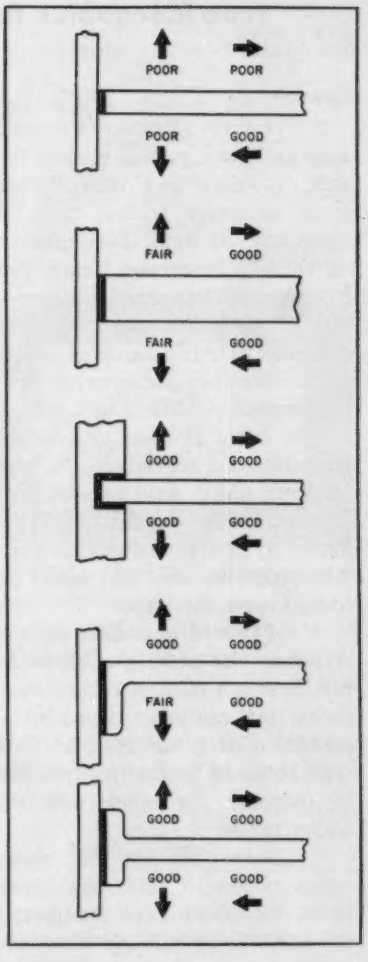
Short-time exposures from 500 to 1000°F can be withstood by these adhesives. Since there are organic substances, this may be the limit which their chemical bonds can take. Recent attention has been directed to development of inorganic adhesives. These are essentially ceramics. Attention has also been given to organics with inorganic additives. Arsenic pentoxide is among the more satisfactory additives. *Text continues on pg. 36*

DESIGN TIPS FOR ADHESIVE BONDING

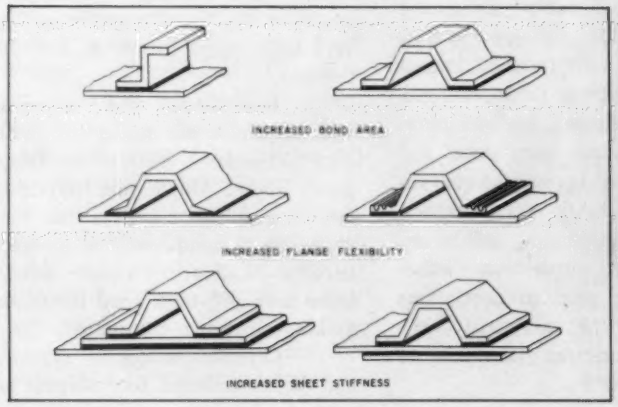
Selecting Best Flat Joints



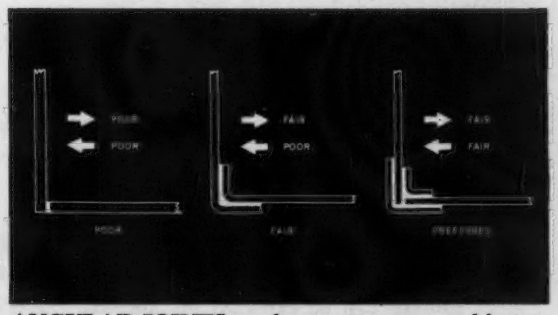
Stress Resistance In Angle Joints



How To Minimize "Peel" In Stiffening Members



Stress Resistance In Corner Joints



ANGULAR JOINTS, such as corners, are subject to peel, or cleavage stresses. It is difficult to eliminate. Best alternative is to design joints that reduce this effect.

Organic-inorganic blends are next step, true inorganics final goal

Epoxies

Epoxy adhesives are available as heavy pastes, viscous liquids, powders and sticks. Their great advantage is that they are essentially all solid. They give off no volatiles on curing. Hence, they have low shrinkage.

Liquid and paste types usually need to have a hardener added, and come as two-part systems. They have a short pot-life (1 to 4 hr) and can be cured at room or elevated temperature, depending on the hardener added. Acid anhydrides or aromatic diamines are used for hardeners in high-temperature cure. Alaphatic amines are used for room-temperature cure.

Powered and stick epoxies do not require addition of hardener. But, heat is a must in curing. And, curing time can be shortened by increasing curing temperature. Care must be taken because it is possible to overcure the bond with the higher temperatures.

Shear strength in epoxy bonds ranges to 1000 psi. Those cured with heat have the greater strength. Even though they are called thermosetting, strength falls off rapidly above 212°F.

Disadvantages are mainly poor impact and peel-strength. Certain forms are vulnerable to grease and oil. Peel-strength can be increased by compounding with flexible polymers. However, the thermoplastic nature of additives reduces strength at elevated temperature.

Epoxy-Phenolic

Recently developed epoxy-modified phenolic adhesives are available as viscous liquids, or supported films and tapes.

Liquids can be expected to have a shelf life of 3 months at room temperature. Some can be stored as high as a year. They can be sprayed or brushed on if a solvent is used. Shear strength is low in comparison to other epoxy-phenolics.

Tape and film forms are made by combining the base resin with an amine curing agent in hot melt. Fine aluminum powder and stabilizer are added and the mixture is impregnated into a thin glass-fiber mat, or made into a film. Tape must normally be stored in refrigerated conditions.

Heat and pressure are necessary for curing. The epoxy-phenolics bond aluminum, magnesium, titanium, steel, and brass. They also bond to glass, and phenolics, but are inadequate for Teflon, silicone rubber, and Kel-F. They generally display shear and tensile strengths over wide temperatures. Peel, bend, and impact strengths are poor. Epoxy-phenolics are relatively expensive but the cost is warranted for areas that will operate above 300°F.

Nitrile-Resin Adhesives

High bond strengths are obtained with nitrile-resin adhesives. Tensile strengths range from 4000 to 8000 psi, and shear strengths approach 4000 psi. Impact strengths, fatigue properties, and resistance to cold flow and creep are also good. Some compounds, however, produce bonds that become relatively brittle at approximately minus 70°F, with reduced impact strength and lower shear strength. On the other hand, high-temperature strengths are very good and most of the compounds have superior heat-stability in comparison to other metal-bonding adhesives. Thermosetting nitrile-resin adhesives may be used in continuous service at 250°F, and will withstand brief exposures with moderate stresses to 500°F.

Vinyl Formal-Phenolic Adhesives

This is the thermoplastic-thermosetting class. The various compounds that come into this classification are available in 3 forms:

- Solvent solutions for brush, spray, or roller coating.
- Fabric tape, coated on both sides.
- Two-part, liquid phenolic resin and vinyl formal powder.

In using the two-part product, liquid is spray, brush, or roller coated on the part. Powder is then sprinkled on the liquid and excess blown or shaken off. Heat and pressure are required for cure. Curing temperatures of 250 to 300°F are customary, but in some cases have gone as high as 500°F. Pressure, as in any system varies with part size and configuration.

The adhesives are durable, and resist most environments and chemical agents. The type of formulation governs thermoplasticity. Strength values vary a great deal. Hence, high-temperature creep can be expected in some compounds. Fatigue properties are good, as are shear and tensile. In aluminum bonds, shear can be expected to be 3000 to 5000 psi, and tensile up to 4500 psi.

Newer Adhesives

Modified acrylate adhesives are promising for structural applications. They are mostly liquid. Like paste epoxies, they require no heat, and only contact pressure to cure. While fabrication costs are low with this type, material cost is very high. Aging properties are not the best.

Inorganics, and organics with additives are noted for their heat resistance. Interest in them grows daily. Magnesium oxychloride is a two-part system that has given good bonds with glass and ceramic. Litharge-glycerine adhesives have provided good bonds in making electronic equipment.

Organic - inorganic systems can be considered forerunners of

the true inorganics. They will probably be perfected first. Studies now center around adding metallic oxides to the organic systems. Arsenic pentoxide has given good results. Amount of additive ranges from 32 to 48 per cent depending on the base adhesive. The oxide was first thought to be an antioxidant. But now, it is believed that the oxides of antimony, vanadium, barium, and zinc are actually curing agents for epoxies and form complex polymers. Epoxies modified with metallic oxides retain 75 to 85 per cent of their strength after "long-time" exposure to 600°F.

Variables In Hi-Temp Failure

Developing an adhesive to withstand high temperatures is no simple task. Once developed, it won't work in every case. Recent substantiating evidence has been given (NASA Tech Note D-108) to show that the nature of the surface being bonded greatly affects deterioration. As an example, an epoxy (tetraphenyl - ethane) was shown to deteriorate rapidly at 550°F in stainless - to - stainless bonds, but resisted 600°F well in aluminum bonds.

In general, an unsaturated carbon-to-carbon bond in a polymer gives high thermal resistance in bonds to stainless steel.

Cross-linking epoxy resins with polyamide, and vinyl copolymers with anhydride side groups increases thermal resistance, especially in stainless-steel bonds.

Fabrication Variables

Fabrication variables have a great effect on the strength of bonded joints. Aerojet-General recently investigated four of these to get maximum quality in the space hardware it manufacturers. Variables concentrated on were: (1) surface condition of adherends, (2) air entrapment in liquid epoxy-base adhesives, (3) use of primer coats and their degree of cure, (4) amount of pressure used in the curing cycle.

Two epoxy-base adhesives were used in measuring the variables: Epibond 100 (Furane Plastics Inc.) and AeroREZ-E101 (Aerojet-General Corp.). Epon VIII (Shell Chemical Corp.) FM-47 tape (Bloomingdale Rubber Co.) and KB-1 were also examined with heat-treated 4130-type steel.

Tensile-shear strength was significantly increased by:

- Surface treatment with Pre-Bond 700 (Bloomingdale) for all adherends. This includes steel alloys, titanium, beryllium, and nickel.
- Use of a vinyl-phenolic primer (FM-47).
- Complete evacuation of entrapped air.
- Curing powdered epoxy-base adhesives (Epibond 100) under 15 psi.

Some specific values are given in the tables.

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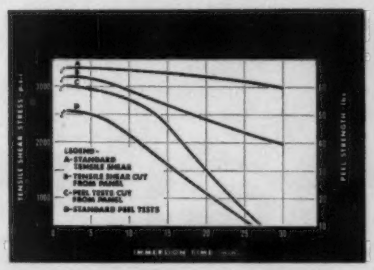
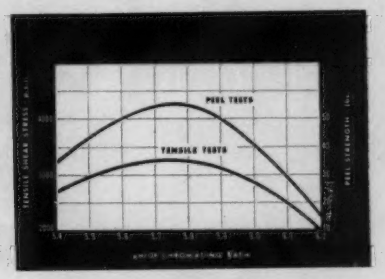
EFFECT OF CURING PRIMER USED WITH AN EPOXY ADHESIVE

Adherend	Average Tensile-Shear Strength (psi)					
	Primer Dried Only			Primer Fully Cured		
	R.T.	120°F	180°F	R.T.	120°F	180°F
7075-T6 Aluminum (0.016-in. thick)	—	3290	3860	—	4950	4490
High-Strength Steel (0.008-in. thick)	5610	4580	3720	7100	4920	4550

Note: All adherends were dip-primed in FM-47 primer prior to preparing lap-shear specimens (¼-inch overlaps) with Epibond 100 adhesives. Aluminum adherends were surface-prepared using FOREST PRODUCTS LAB *etch treatment. Steel adherends were surface-prepared using Pre-Bond 700 surface treatment. Adherends after dip-priming were dried for 1 hr at room temperature, followed by 10 min. at 250 ± 10°F. Adherends after dip-priming were fully cured (air dried for 1 hr at room temperature, followed by 1 hr at 340 ± 10°F).*



EFFECT OF DIP TIME in hot chromate on bond strength of ZE-41 magnesium. Adhesive, Narmco's 4021 Metlbond on 1-in. strip.



EFFECT OF pH in chomate bath on bond strength of ZE-41 magnesium. Adhesive, Narmco's 4021 Metlbond on 1-in. strip.

HOW BOND STRENGTH VARIES WITH SURFACE TREATMENTS

Surface Treatment	Tensile-Shear (psi)
Pre-Bond 700	8200
Trichloroethylene vapor degrease	3400
Vapor degrease, sandblast, vapor degrease	3400
Scuff sand, vapor degrease	3400
Dilute HCl	3400
Wipe with ketone	3200
Oxalic-sulfuric acid	3100
Chromic-sulfuric acid	3000
Dilute sulfuric acid	3000
Dilute HF	2200
Vapor degrease, alkaline degrease	1800
Alkaline degrease	1600

Note: Specimens were ¼-in. overlap, using 0.010-in. thick steel strip adherends (C-1065 type with 2 percent Ni). Strips were primed with FM-47 liquid adhesive and joined with Epibond 100.

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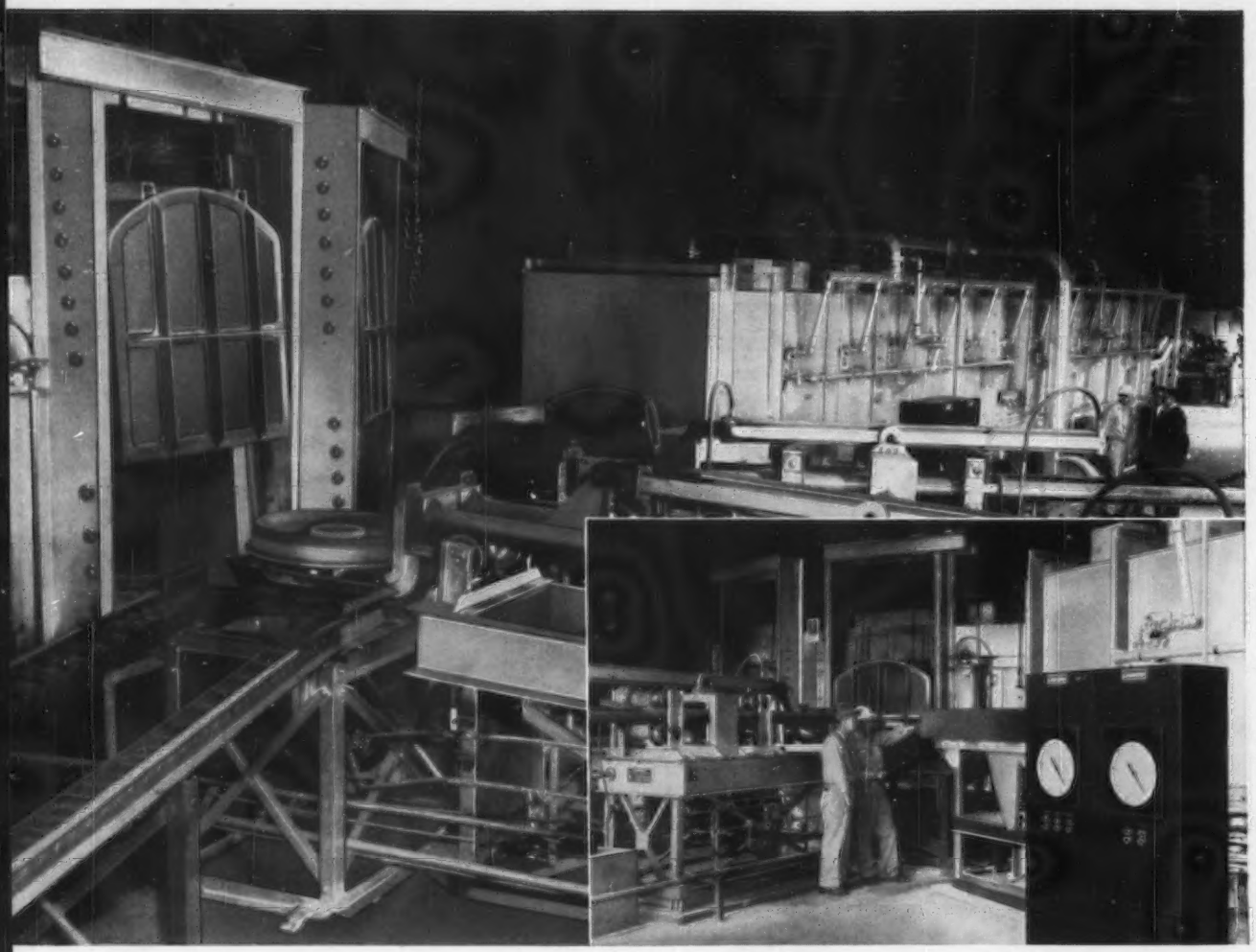
BIG JOBS ARE PART OF LINDBERG'S

Complete, automated heat treating installation at Griffin Wheel designed and installed



Several years ago, Griffin Wheel Company's plant at Colton, California began heat treating car wheels in a Rotary Hearth Furnace designed and installed by Lindberg Industrial Division. It was one of four similar installations at other Griffin plants in United States and Canada. Recently, when production at the Colton plant needed to be doubled, Griffin again called on Lindberg Industrial engineers to develop the necessary methods and equipment. The desired result was accompanied by a specially designed Preheat Furnace shown at the right above, engineered and installed by Lindberg Industrial and automated to work efficiently with the original Rotary Hearth Furnace. Inset shows the Lindberg control panels conveniently installed for operation of both furnaces.

The operation of both furnaces was completely automated. The above photo shows the charging of the Preheat Furnace and the automatic conveyor which moves the wheels through the Preheat Furnace and delivers them to the Rotary Hearth Furnace.

The original Rotary Hearth Furnace at Griffin has an outside diameter of 44'. Initial capacity of 13,000 lbs. per hour was doubled with the installation of the new Preheat Furnace.

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by Lindberg Industrial Division

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Our experience covers the whole range of industrial heating methods so you can rely on us to recommend the processes most suited for your specific need.

Whatever size your installation need be, no matter how rigid your quality specifications are, turn the complete job over to Lindberg. You'll be happy with the results.

Lindberg Field Engineers are available in 23 major industrial centers in this United States and Canada (see classified telephone directory) or write direct to: Lindberg Industrial Division, Lindberg Engineering Company, 2321 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg, Ltd., Toronto.

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heat for industry

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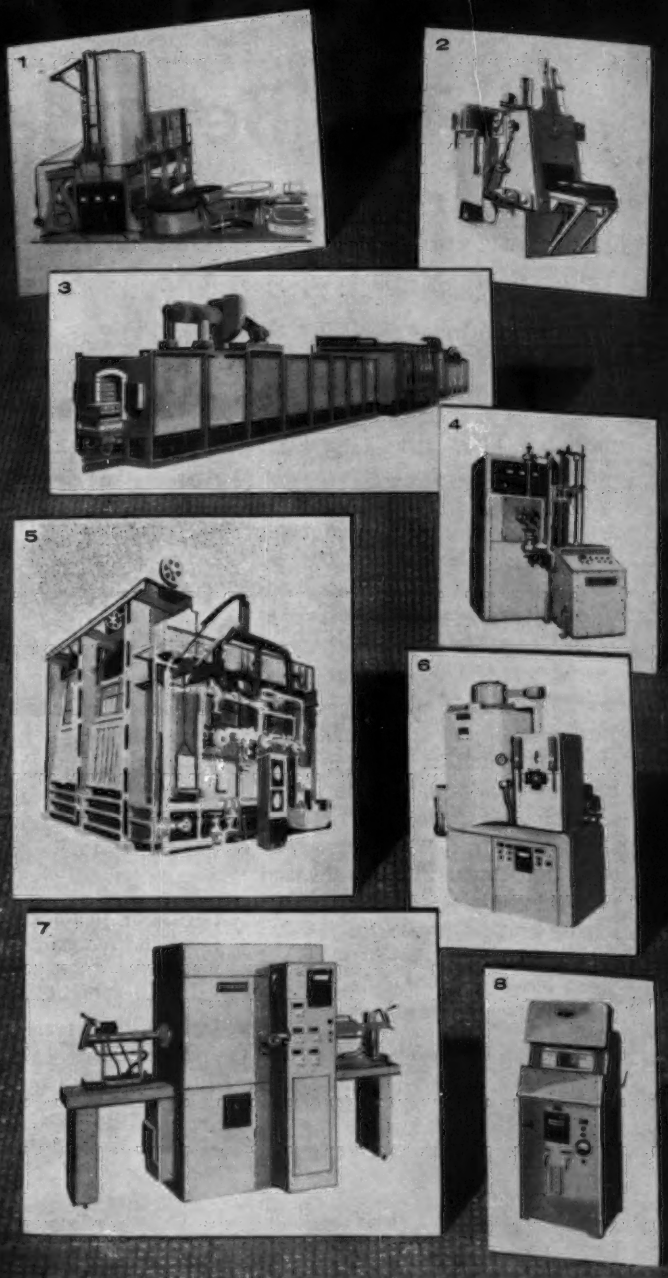


1 Gantry Type Furnaces: Lindberg Industrial Division has installed a number of Gantry Type Furnaces with auxiliary equipment for heat treatment of missile and rocket components.

2 Heat Treating Furnaces: For every requirement, large or small, electric or fuel fired, factory built or field-installed. Shown: Automated Integral Quench Type Carbonitriding Furnace.

3 Ceramic Kilns: All types of kilns: automatic, atmosphere controlled, high temperature, tunnel and periodic. Shown: Tunnel Kiln with two automatic control zones for temperatures up to 3200° F.

4 High Frequency Units: Complete range of induction heating units and furniture. Shown: New Floating Zone Scanner for production of hyperpure materials for semi-conductors.

5 Melting and Holding Furnaces: Equipment for any non-ferrous metal requirement including electric resistance and two chamber induction types, reverberatories, dry hearths and crucibles. Shown: Field-installed Reverberatory Furnace, 80,000 lb. capacity.

6 Atmosphere Generators: Generators for all required furnace atmospheres. Shown: Hyen Generator for endothermic atmospheres.

7 Pilot Plant Equipment: Complete group of intermediate sized furnaces for pilot plant and small production application. Shown: New Graphite Tube Furnace, temperature range 2500° F. to 5000° F.

8 Laboratory Furnaces: Complete line of laboratory furnaces from simple hot plates to specialized research units. Shown: Versatile, wide temperature range Laboratory Box Furnace.

Circle 22 on Inquiry Card

INDUSTRY TESTS REVEAL

The Best Plastics for Rockets and Re-entry

Resin molecules should be highly cross-linked and give max carbon residue after ablation; Nylon reinforced phenolics good in nose cones, but are outperformed in rocket motors

A decade ago designers regarded plastics as controversial engineering materials. Through "trial-by-fire," plastics have since gained a prominent place in re-entry shields and rocket structures. In these applications they ablate, and protect underlying components from intense heat.

DISCOVERER RE-ENTRY SHIELD is tape-wound, by The B. F. Goodrich Co., with Nylon-reinforced phenolic material. Phenolics display desirable properties for ablation; they convert 100 per cent into carbon during re-entry.

Physical Aspects

Ablation is the wearing away of a solid surface by a high-speed fluid.

Some generally desirable traits of ablation materials are:

- A large amount of vaporization to thicken the boundary layer and reduce rate of heat transfer. Vapor products of low molecular weight enhance this effect through their greater heat capacity and diffusion coefficients.
- Good thermal insulation characteristics so as to confine the ablation process and its damage to the surface.
- High resistance to thermal and mechanical shock, and fabricability in large sizes.

Among the prodigious family of plastics, reinforced plastics are finding extensive high-temp applications by meeting the above requirements.

Ablation of reinforced-plastic surfaces involves one or more of the following phenomena:

- Melting of ceramic fibers
- Vaporization of molten ceramics
- Pyrolysis of resins in the matrix
- Melting and pyrolysis of polymeric fibers

Ablation of Teflon

Among early plastics considered for protection from aerodynamic heating was Teflon. Tests show that ablation of Teflon occurs by a first-order reaction of depolymerization. Resulting monomer usually flashes into vapor, and about 750 BTU/lb are absorbed. The monomer gas may then react with itself to produce unsaturated heavier molecules. In high-temperature air, the monomer may also dissociate and burn, forming COF_2 or $CO + F_2$. Teflon remains at its initial temperature a few millimeters below surface, and a steep temperature gradient prevails on the surface. This means heat absorption by depolymerization occurs mostly near the surface.

Chemical Aspects of Ablation

Heat attained in re-entry and rocket exhausts can generally decompose all organic matter. However, with the brief exposures common, large differences in ablation rates occur with various resin systems. These are attributed greatly to resin chemistry.

Decomposition during ablation depends on rate of heating, time of exposure, and distance from surface. This makes it difficult to prescribe a definite mechanism for all reactions. Also, oxidation effects at the surface complicate the energy balance by combustion heat released.

Thermoplastics vary in thermal behavior, depending on chemical composition and tendency to cross-link on heating. Certain polymer acrylic resins decompose in vacuo to monomer, with scission occurring at ends of molecular chain.

At the other extreme, polyethylene decomposes to volatiles. Only about three per cent of the volatiles are monomer, the rest are fragments with average molecular weight of 700.

Polystyrene and polyisobutylene yield intermediate amounts of monomer, showing degradation by random and chain-end scission.

Behavior of vinyl choride resins depends on number of chlorine atoms present.

Polyvinyl choride, heated to above 400°C, yields only 15 per cent of original carbon; polyvinylidene chloride converts quantitatively to carbon.

High dissociation energy of carbon-to-fluorine (C-F) bond (107 K-cal/mol) makes Teflon-type resins attractive for their thermal resistance. Under ablating conditions, it is doubtful that the heat absorbing potential of this class of resins are fully realized. Since the carbon-to-carbon (C-C) bond (62 K-cal/mol) is weaker than the C-F bond, degration in Teflon occurs at the C-C bond with formation of tetrafluoroethylene monomer in a molecular chain-end type scission. Very little of the C-F dissociation will occur if the volatile products are swept away by the gas stream. If the C-F bond could be contained at or near the heated surface, Teflon as an ablating material would be more effective. Polyvinylidene fluoride, containing two fluorines to Teflon's four, yields a coke deposit close to 100 per cent of original carbon content.

Mechanical Properties of 37-9X

	Room Temp.	500°F (½ hr)	500°F (50 hr)	500°F (200 hr)	700°F (½ hr)	Boiling Water (2 hr)
Flex. Ult. (psi)	90,046	78,360	76,840	63,420	32,130	81,910
Mef (psi × 10^6)	4.24	3.60	3.72	2.56	2.60	3.97
Tensile Ult. (psi)	48,080	41,480	40,020	34,020	33,030	46,440
Compressive (psi)	49,320	33,660	42,000	30,020	15,818	39,790

Phenolics

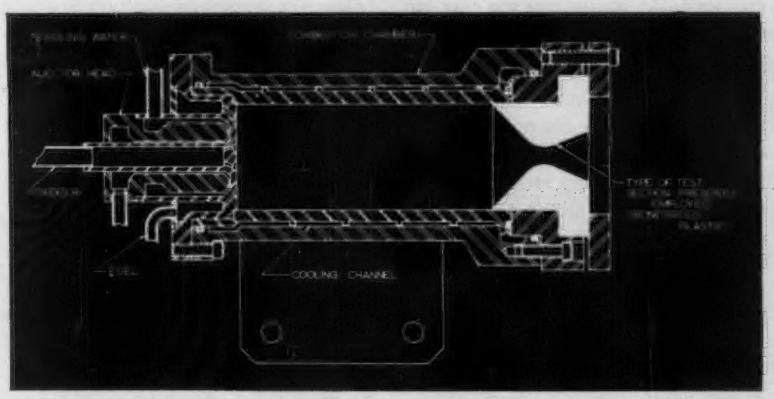
On the basis that high carbon formers are desirable materials for ablation phenolics (convert 100 per cent) should show a high degree of ablation resistance. Lab and rocket-motor tests confirm this expectation.

Phenolic resins vary in structure with type of phenol, phenol-to-formaldehyde-ratio, catalyst, and curing conditions. Long-chain compounds with little cross-linking occur where certain phenols are sterically hindered. This prevents substitution in all three active positions. In such cases, one would expect these long chain segments to break-off with the formation of volatiles. It would be desirable to eliminate such chain formations and attain maximum degree of cross-linking.

In practice, phenolic resins are generally compounded with fillers. Fillers may have catalytic effects on thermal stability of the resin. Evidence shows that addition of small concentrations (1 per cent) of inorganic chemicals to sugar result in close to theoretical yield of carbon residue. Similar effects probably occur in other resin systems, particularly in oxygenated resins in which elimination of water can increase cross-linking density.

Cooling effect of volatiles or gases leaving the resin may help minimize ablation effects. In practice, however, generation of such gases may sometimes have disastrous effects. Behind the surface of the resin, sudden temperature rise may cause destructive distillation of volatiles. Forcibly ejected volatiles may result in voids and sudden loss of surface materials. Thus, molecular structures minimizing the formations of volatiles and favoring a high degree of cross-linking, with attendent high carbon formation, appear desirable.

Higher thermal fluxes generally result in a decreasing ablation rate per heat input. At 5000°K and above, dissociation of gases into atomic and ionic species can occur with the absorption of considerable energy. This would happen at high heating-rates and temperatures; that is, when dissociation occurs at the surface or in boundary layers be-



SPAR MOTOR cross section shows cooling provisions, and functional retention method used for removable nozzle specimens.

Thin ceramic coatings harmful; cause entrapped gas-layer which explodes

fore the decomposition products, from the resin, escaped into the gas stream. An all-organic resin system, such as nylon-fiber-reinforced phenolic, actually outperform the glass-reinforced phenolic at the higher temperature regimes. This is because of the large portions of N_2 and H_2 yielded in dissociation.

Phenolic-Silicone Resin

Recent studies at Cincinnati Testing & Research Labs (CTL) were aimed at extending the high-temp strength of phenolic resin laminates. Investigations included the modification of a phenolic resin by a silicone resin.

As a control sample, 181 glass cloth was impregnated with 91-LD resin (CTL) successful in high-temp applications. To strike an average, four batches were made, of varying resin content, flow, and volatility. One-eighth inch laminates were made using 14 plies of impregnated material. Laminates were formed at 275°F under 200 psi for 40 min; they were post cured for 24 hr at 250, 300, and 350°F. Averaged properties for the four batches were as follows:

	Room Temp.	500°F	600°F
Flex. Ult. (psi)	80,040	54,500	42,900
Mef (psi × 10^6)	4.46	3.78	3.38

Further tests introducing varying ratios of phenolic-silicone showed that complete co-polymerization was not being attained in the cure. Thus, ultimate flexural strength was being reduced. Investigation was undertaken to find an effective cross-linking agent for the phenolic and silicone resins. Seemingly if a material could be found with a phenolic reactive group at one end and a silicone reactive group at the other, greater co-polymerization would be achieved. A series of complex, silane cross-linking agents was tested. The results with one of the agents was good when added in the amount of 1 per cent by weight. The resin was impregnated in glass cloth, and 37-9X material came into existence.

Electrical Properties of 37-9X

	Standard Conditions	Wet Condition (24 hr immersion)
Dielectric Constant	4.52	4.71
Loss Tangent	0.022	0.027

(Specific Gravity 1.77)

The 37-9X material thus achieves a gain of over 25 per cent in flexural strength at 5000°F over 91-LD. The ultimate flexural strengths of 37-9X remains virtually the same after 500°F exposure for 100, 150, or 200 hr. Tensile strength after ½ hour at 500°F was only 6600 psi less than room-temperature strength. 91-LD is used in many existing heat-shields; Atlas Mk-3 nose cone, and Mercury capsule are a few; 37-9X is being studied by both Avco and GE's MSVD.

Plastics in Rocket Motors

Unlike liquid-propellant engines, solid-propellant rocket nozzles are generally uncooled. The nozzle is, therefore, subjected to severe thermal fluxes, and mechanical erosion.

Nozzle materials have various limitations. Some are heat-sink materials suitable only for short durations; some are brittle and subject to spalling during operation; others are very costly, available only in limited quantities; and many are extremely difficult to fabricate into required configurations.

To simulate operational conditions encountered by rocket nozzles, a special rocket motor was designed and constructed at Aerojet-General. This test unit, designated the Structural Plastics Ablative Rocket (SPAR) utilizes gaseous oxygen and gaseous hydrogen as oxidizer and fuel, respectively. The SPAR motor is designed for firing with a stagnation temperature controlled from 2000 to 6000°F, and a chamber pressure controlled from 50 to 800 psig. Prospective materials are fabricated into small test nozzles and installed directly into motor. Throat diameter of test nozzles are from 0.25 to 0.75 in.; firing duration is controlled automatically or manually, depending on type of data desired.

Relative Performance of Resins in "Spar" Nozzle Test

Resin	Type	Rating*
Phenolic	High-temp.-resistant	5
Phenolic-silicone	High-temp.-resistant	5
Epoxy	Std.; cured with aromatic amine	3
Melamine	Std.	3

** Based on firing duration under controlled motor operating conditions (theoretical flame temperature—5400°F; initial chamber press.—525 psia; nominal shut-down chamber press.—300 psia; 0.25-in. throat diam). Best material in this series is rated 5; others are rated proportionately lower, depending upon firing duration.*

To evaluate nozzle materials, the actual rate of ablation is determined. The decrease of chamber pressure with time (due to increasing throat diameter) is measured. If the performance of a specific rocket nozzle or design is being studied, the total ablation must be considered. In such cases the motor is fired under specified operating conditions, and the over-all change in performance (pressure drop) is evaluated.

Experience had shown that high-temperature resistant, glass-reinforced phenolic resins were reasonably satisfactory for thermal insulation in short-duration rocket motors. However, little information was available on performance of materials under the severe operational conditions. Accordingly, a program was initiated to evaluate the following variables in the fabrication of plastic rocket nozzles: (1) resins, (2) reinforcements, (3) fill-

ers, (4) protective coatings, (5) molding and post-curing conditions, and (6) orientation and form of reinforcements.

Initial studies established testing variables and procedures, and provided information on the general characteristics of specific classes of materials. A summary of the Aerojet work follows.

Resin In Rockets

Typical commercially available resins were fabricated into test nozzles, primarily using chopped Refrasil fabric. Included were heat-resistant phenolic, phenolic-silicone, and amine-cured epoxy. Curing cycles were those recommended by resin manufacturers. A commercial melamine-glass fabric laminate was also tested and compared with phenolic-glass. Results indicated that heat-resistant phenolic and phenolic-silicone resins are essentially equivalent in performance, and substantially superior to the melamine and epoxy resin systems evaluated. (In this initial study, no attempt was made to thoroughly investigate various types of epoxy resins and curatives. Improvements may be anticipated with the more heat-resistant grades.) Based on these tests, heat-resistant resins appear most desirable for nozzles. However, there is not yet sufficient evidence to conclude if the observed differences in performance are due to molecular structure of resin or mechanical strength at elevated temperatures.

Reinforcing Agents

Glass fabric is the principal reinforcement used in rocket motors. However, asbestos, Refrasil, and organic fibers have also indicated promise in similar applications. Fibers of metals and ceramics were also considered worthy of investigation as reinforcements for plastic nozzles. In relative performance tests, Refrasil excelled. This was reflected by visual appearance of nozzles sectioned after firing. Specimens using Refrasil retained greater charred material than those using the standard "E" glass reinforcements. This is probably related directly to Refrasil's higher softening temperature, melt viscosity, and possibly superior wetting or surface tension at high temperatures. The lower coefficient of thermal expansion, α, of silica glass may also be a significant factor, resulting in a lower thermal stress factor (product of α and modulus of elasticity). The superior reinforcements possibly form a protective surface layer which acts as a heat-absorptive thermal barrier. Also, the reinforcement fibers maintain continuity and mechanical strength in regions below this protective surface layer.

The relatively poor performance of the phenolic-impregnated nylon fabric nozzle may be due to the particular temperature (5400°F) conditions encountered. Other investigators have also found that organic fibers, such as nylon, are optimum at much higher temperatures (about 10,000°F). To further examine this behavior, a test nozzle was fabricated of alternate ⅛-in. layers of nylon and asbestos fabric reinforcements, impregnated with a heat-resistant phenolic resin. An improvement of about 40 per cent was observed over the nylon-fabric, reinforced-phenolic nozzle. Also, upon sectioning of this specimen after firing, a substantially greater ablation was noted in the nylon fabric layers than in those of asbestos.

It is interesting to note that the "life" of nozzles containing the various reinforcements appears to be inversely related to the thermal conductivity of the reinforcing agent.

Tests, with thin refractory coatings on Refrasil-phenolic nozzles, gave poor results. Gases, from decomposed resin, ruptured the coating and caused asymmetrical-thrust conditions.

Molding variables, especially temperature, pressure, and time, can markedly influence physical and thermal properties of a reinforced plastics. Results of a limited number of tests indicate that performance of phenolic-Refrasil-base nozzles may improve asymptotically with increasing molding pressure. Seemingly, the thicker the nozzle wall, the greater the benefit of higher molding-pressures. Postcuring appears to have only minor effect on performance, so long as the unit is mechanically sound and dense.

Orientation and Form of Reinforcement

Nozzle specimens were fabricated to determine influence of the form and orientation of reinforcement, consisting of: (1) compression-molded bulk Refrasil-fibers, (2) Type 182 Refrasil-fabric laminate, (3) Type 182 Refrasil fabric, cut into ½-in. squares, and molded, (4) circumferentially wound Refrasil roving, and (5) circumferentially wound Refrasil cordage. A heat-resistant phenolic resin was used in every case. Test results show that flatwise lamination or molding is desirable, to produce fiber orientation essentially normal to gas flow (edge-grain effect). Other investigators have reported similar observations. Material laminated parallel to gas flow (parallel-grain effect) tends to fail due to inter-laminar stresses and successive peeling of reinforcement layers. Edge-grain reinforcements permit the gaseous decomposition products to more easily escape, without disrupting the structure. In addition to these mechanical aspects, differences in physical properties may also help to explain the observed results. For example, the thermal conductivity of edge-grain material is about three times higher than that for parallel-grain; hence, the effective heat capacity of edge-grain material is substantially greater.

This article is based on research reports from: MSVD, General Electric Co.; CTL, a Division of Studebaker-Packard Corp.; Aerojet-General Corp.; and U. S. Navy Bureau of Weapons.

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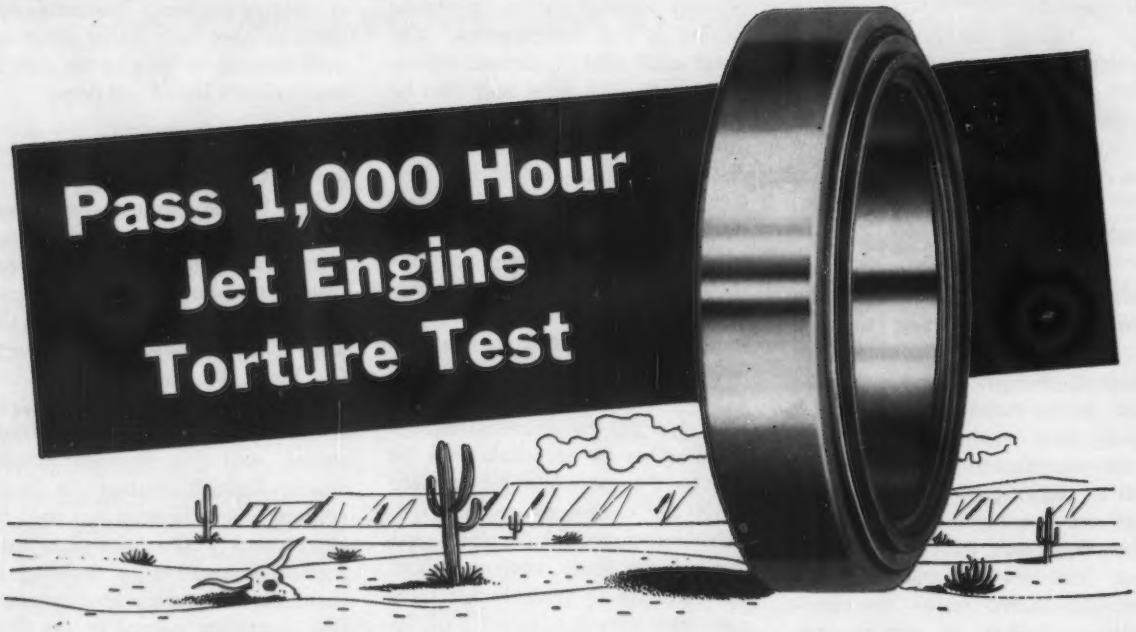
SEALOL MECHANICAL SEALS



Conditions: 7,000 RPM 250°F. 0-250 PSI cycling pressures

Results: *NO SIGNS OF WEAR – ZERO LEAKAGE*

Picture a ¾" jet engine pump shaft running bone dry at 7,000 RPM, temperatures to 250°F. . . . hour after hour. Suddenly, water surges into the pump, slams into the shaft seal with momentary pressures running to 650 PSI. For 2 minutes, water is pumped at 250 PSI, then back to 4 hours of dry running.

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YOUR PARTICULAR SEALING PROBLEMS . . . may or may not call for "one thirteen" treated seals . . . or welded metal bellows seals . . . or heavy duty Flexibox-type seals . . . or low cost RS seals.

The important point is that you can look for longer life, lower costs and better performance when you contact your nearest Sealol Engineer for detailed information and recommendations.

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CURRENT APPLICATIONS

RPM	Shaft Size	Temperature	Fluid	Pressure
51,000	1 3/16"	400°F	Peroxide steam and nitrogen	0-10PSI
17,000	3"	225°F	Air Oil Mist	2-3PSI
37,500	1"	650°F	Mil-O-5606	20-30PSI
13,800	1 11/16"	—300°F	LOX	50PSI
3,500	1⅜"	270°F	Acetone, H2S04 and Phenol	80PSI
1,750	1⅞"	100°F	Mercury with 5% water	160PSI
173	1"	210°F	Tomato products	30PSI
25	1¼"	Ambient	Heavy Water	150PSI

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How To Get More 'Weapon System' Per Dollar

Task force approach to value analysis and nationwide cooperation of subcontractors have saved Air Force $25 million

by S. Peter Kaprielyan

Everyone talks about inflation, but few do more than accept it as an inevitable economic trend. Republic Aviation has officially declared war on rising costs since last June.

This was done through the voluntary support of major suppliers, and the blessings of the Air Force. Savings derived thus far are reported as over $25 million on the F-105 program.

Delegates from the "nationwide team" producing the Mach 2 Thunderchief gathered recently at Farmingdale for an accolade. They were told by E. I. Little, director of material for Republic, that their teamwork had achieved an overall 19.99 per cent cost reduction in eight months.

Goal Is 30 Per Cent

The program was initiated with a cost reduction goal of 30 per cent. To date, only one major supplier has accomplished the objective. This is the Armament and Control Section of the Light Military Electronics Dept. of General Electric.

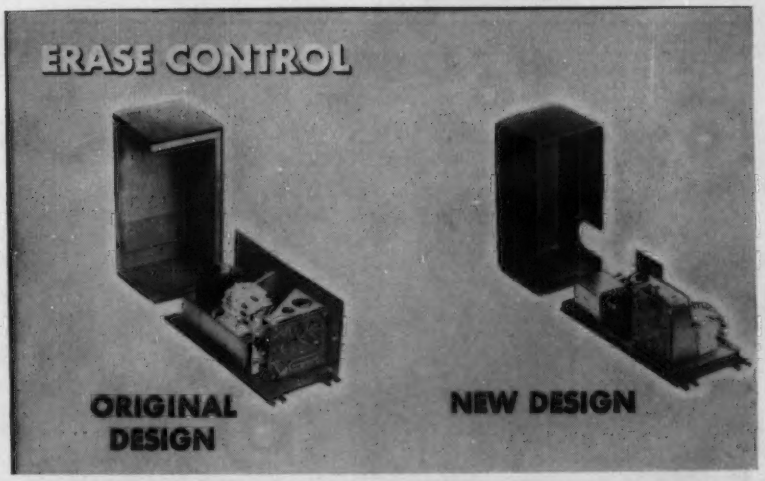
An intensive, in-plant cost-awareness program was started by GE and expanded to second-echelon major suppliers. Exploration of all possible cost-reduction avenues was launched with the battle cry "F-105 Minus 30" (let's reduce costs on the F-105 by 30 per cent).

M. R. Johnson, manager of Armament and Control Section, outlined the campaign as follows.

• A special Cost Reduction Task Force of four men was established, with a chairman reporting directly to manager. These men, of a critical inquiring nature, were selected on a full-time basis: an experienced purchasing man to represent manufacturing, a cost man from finance, the marketing man on the F-105 contract, and an experienced engineer. Task Force was charged with responsibility of "implementing a full-scale cost-improvement program on all equipment furnished for the F-105." Line managers were urged also to cooperate with the investigations.

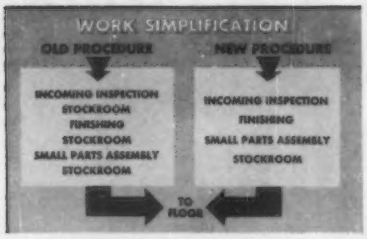
Text continues on next page

PAINTED BLACK AND YELLOW stripes on switch handle were replaced with time-saving decal.



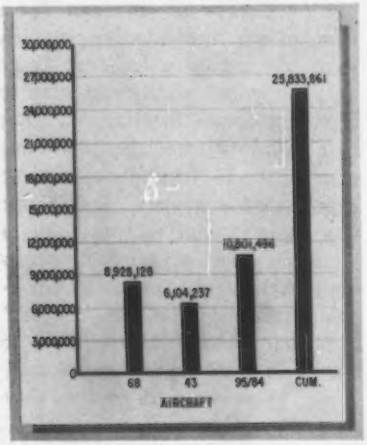
QUESTIONS ASKED were: Why is unit cover broken this way? Is cooling air really needed? Why are components mounted on a bracket? Answers reduced sheet-metal costs from $54 to $15 per unit.

How one contractor reduced costs over 30 per cent on F-105



ANALYSIS REVEALED that sheet material made three trips to stockroom during processing; new, streamlined routing system is now saving about $8000 per year.

CUMULATIVE SAVINGS DUE TO COST REDUCTION PROGRAM—$25,833,861



• First action of Task Force was to establish the "battle cry."

• Second action was to develop widespread general support for the effort. This was done by special publicity and stressing suggestion award campaign. This phase proved specially effective.

• Third action was to initiate a thorough and detailed examination of eighteen major subassemblies supplied for F-105. A team was formed of working-level experts responsible for each components. Members were: the assembly planner, the machine planner, the production engineer, and the quality control engineer.

Cost Reduction on F-105 Weapon System Covers the Following Categories

Category	% Reduction	$ Savings (approx.)
Subcontracts	15.5	2.5 million
Equipment	12.9	3.5 million
Electronics	21.5	3 million
GFAE	21.9	16.5 million

Creative Approach Used

Close liaison with both purchasing and cost personnel was provided to each team. One problem was to prevent over-familiarity from hampering the flow of ideas. To this end, a value analysis engineer was added to each team to ask all the wrong questions and to stimulate new approaches.

Teams were supplied with part lists and costs for their subassemblies. Most energetic "spark plug" in each team was designated "Team Captain," and charged with getting effective output from group. Each team worked, part of a day, in an isolated conference area without telephones.

Within Republic itself, the program has made progress in several areas. New, overall budgets have been established for each of the 17 shops or departments. These include controls for materials, manhours, procurement, etc.

Partial returns on results show:

- Man-hours for nose-splice structure area, per ship were reduced from 3815 to 1890.
- Wing section man-hours were reduced from 2046 to 1273.
- Some 4000 hours were saved per ship through tooling improvements.

Substantial cost reductions were also achieved by the following subcontractors: Cessna, making rudders, stabilizers and fins—16.2 per cent; North American's Autonetics division, making radar units —8 per cent; Kearfott, a supplier to both General Electric and Laboratory for Electronics (LFE), making doppler radar unit—30 per cent on material supplied to GE, and 12.5 per cent on units supplied to LFE.

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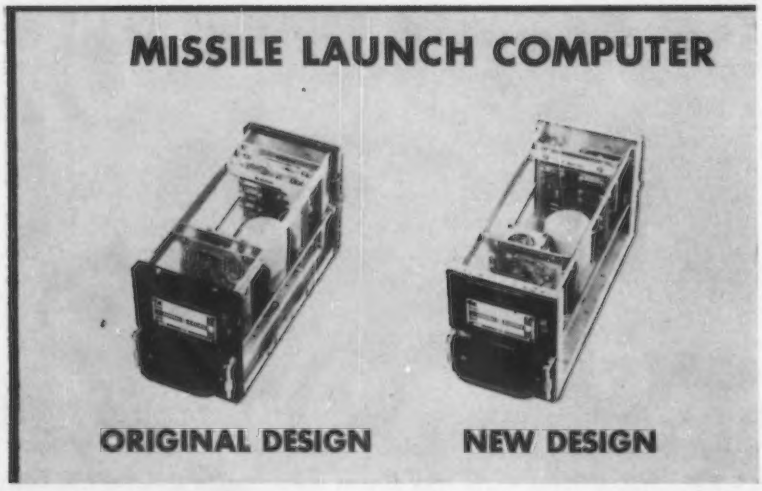
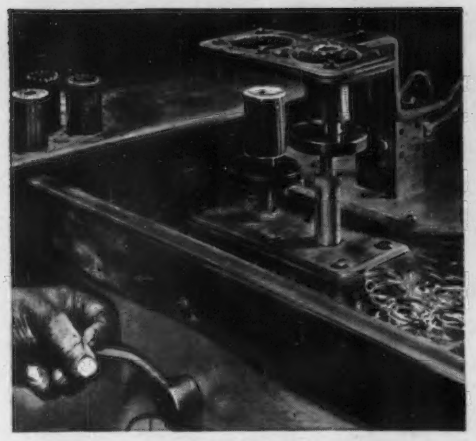
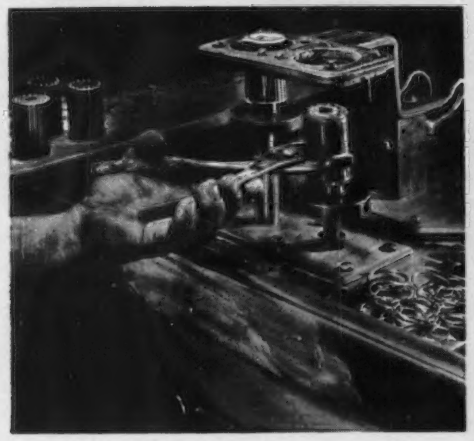
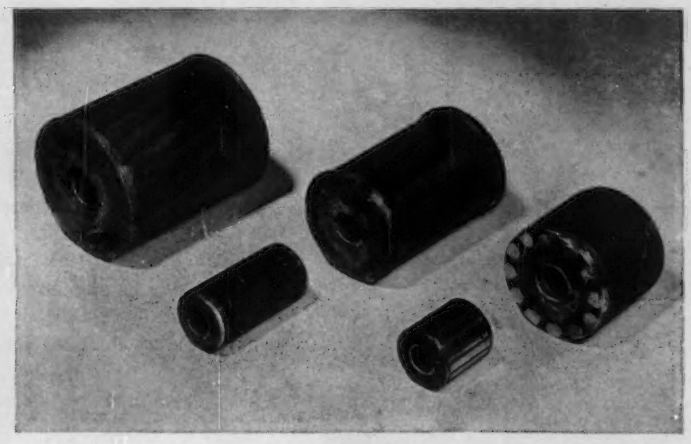


CHASSIS REDESIGN, and use of aluminum dip-brazing instead of arc welding saved $63.70 per unit.



Handy & Harman Sil-Fos Silver Brazing is Used by Induction Motors Corp. in 5427 Different Motors





FIRST, BULLETIN 20

This informative booklet will get you off to a good start on the values, techniques and economies of low-temperature silver brazing. A copy awaits your request.

Induction Motors Corp. of Westbury, New York, and Maywood, California, has built an outstanding reputation as a designer and manufacturer of sub-fractional horsepower motors...for 5427 high performance reasons.

This large variety of motors, blowers and fans for an equally large variety of applications, stems from 15 basic motor frame sizes, depending on length, pole materials, windings, groove angles and the like.

Handy & Harman silver alloy brazing is concerned with brazing the rotors. Each rotor (whatever the size) is joined by a preformed ring of Handy & Harman SIL-FOS, by induction heating – at an alloy cost that is reckoned in pennies. For example, the alloy cost per ⅞" frame is two cents per joint, or four cents per complete assembly.

That's an example of the economics of silver alloy brazing. Performance requirements are quite another thing – and they are unquestionably stringent. Many of these motors are used in aircraft and missile work and must, of course, meet the most extreme environmental conditions.

Strength alone would be reason enough to discuss the merits of silver alloy brazing... and to point out as a reason for its wide acceptance throughout industry. The facts are that there are many more benefits; gas- and leak-tightness, thermal and electrical conductivity, ductility, and production economy – are all *joint qualities* of silver alloy brazing. At any time, we will be happy to discuss any or all of these qualities (and others), as applied to your product or production method. The benefits are large and you can enjoy them.

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What Protects the Payload?

Tape-wound laminates give long-sought solution to problem of light, strong ablation heat shields for reentry

by John P. Kushnerick

MARK-3 NOSE CONE with ablation heat shield rides on latest Atlas models. Cylindrical section and frustum after-body are made by tension, tape winding. Nose dome is still made by hand layup. Material is nylon reinforced CTL-91-LD.

In August 1959, Aircraft & Missiles published the first detailed account of the design and manufacture of the heat-sink nose cone. Now, in another staff written article, comes the first similarly detailed story on the ablation heat shield, successor to the heat sink.

Laminates of phenolic resin and various reinforcing agents have proven extremely effective as ablation heat shields for reentry. A process called "tape-winding" has proven similarly effective in manufacturing these huge laminates. B. F. Goodrich, in adapting this process to semi-automated machines, has advanced the state-of-the-art one degree beyond those using a hand layup version of tape winding.

At Goodrich's Aviation Products Div., where parts are being made for the Atlas Mk-3 ablation shield and Discoverer capsule, impregnated cloth up to 12 in. wide is wound over a mandrel under tension at speeds up to 50 ft/min. After winding, parts are bagged, cured in an autoclave, and machined to final dimensions. Since certain tape-wound laminates have limited structural strength they are adhesively bonded to other metal or filament wound base material before use on nose cones.

Tape winding under tension has these advantages:

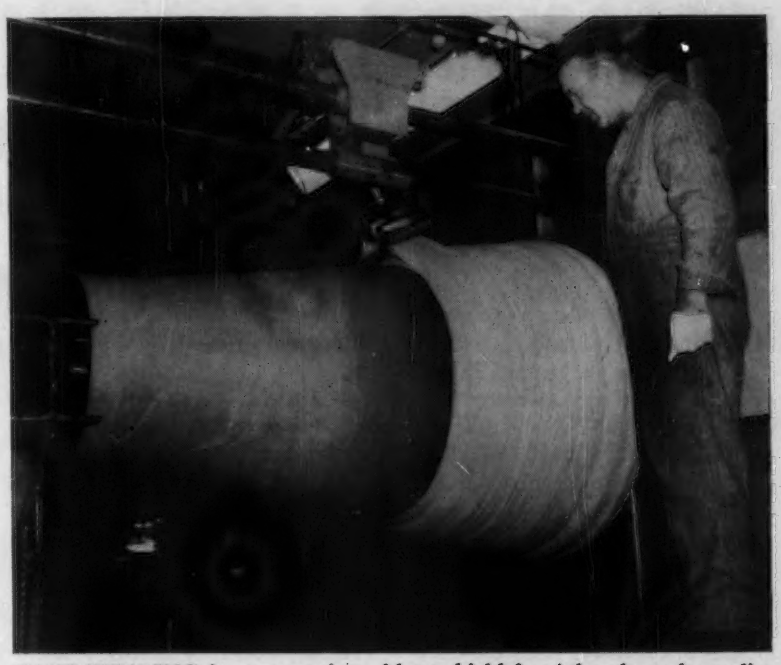
- Applies large bulk of material rapidly.
- Part is a nearly homogeneous mass immediately after winding. Hence, is void-free.
- Tape can be wound to orient laminate plies at angles of 15 to 30 deg to mandrel axis. This gives optimum ablation characteristics on reentry.
- Versatility, since design changes to make part larger simply by winding an excess of material on the mandrel, then machining to final dimension after cure.
- Speed of fabrication over other methods.
- Eliminates costly matched dies.

The Materials

The process is adaptable to a wide range of materials. Glass cloth, Refrasil, nylon cloth, and asbestos have been used as reinforcing agents. Best results were achieved in the past with glass cloth. Current interest in nylon cloth by nose-cone prime contractors has resulted in perfecting techniques with this material. Nylon is attractive because it is cheaper and lighter than

some of the others, yet performs well in ablation tests. Some limitations are imposed on tape winding by Refrasil and asbestos. They cannot withstand the tension required. Backing material (112 glass cloth) has been used in some cases to give strength.

Cincinnati Testing Lab's (CTL) resins, namely CTL-91-LD, and the new phenyl silane 37-9X best meet the specifications of the prime contractor Goodrich serves on present parts. These resins have, therefore, received most attention in tape winding. However, other resins have been used. These are: (1) Cordo's Pyropreg AC, (2) Dow's DC-7141 and DC-silicone resins, (3) Bakelites BLL-3085, (4) Monsanto's SG 1013.



TAPE WINDING frustum section of heat shield for Atlas shows how plies are angled to give a "shingled effect." Keeping phenolic-impregnated nylon cloth under tension makes part a nearly homogeneous mass, give better strength in final part.

The Process

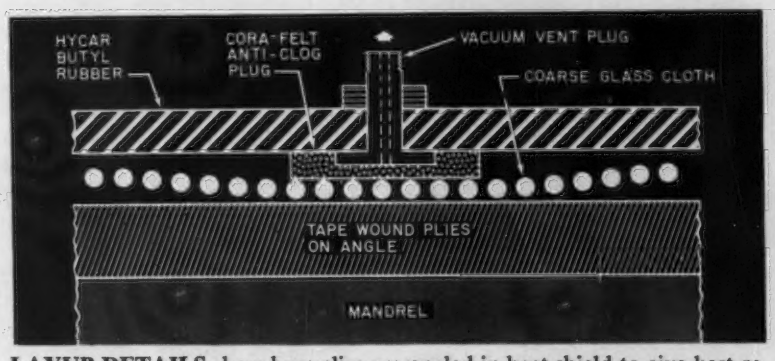
Materials used in tape winding are received from U. S. Polymeric, Cordo, or American Reinforced Fabric, where the resin is preimpregnated into the reinforcing agent.

Goodrich commences its process by first preparing the mandrels. (Mandrels are constructed of hot-rolled steel plate, welded pressure tight. Mandrels are then normalized, rough machined, normalized again, then machined to final dimension. Present mandrels weigh about 1000 lb.) Parting agent is applied to the mandrel so that the finished part can be removed easily at the completion of the cure. Rubbing carnauba wax on a preheated mandrel has been as effective as any commercial release agent.

An initial hand layup, or a few plies of "parallel wind," is first applied where the angle orientation of the final plies is severe, or critical. This will prevent slippage of the final, angle-oriented plies. No special holding requirement is needed to start the wind. After the first several turns, the starting end is held firmly in place.

Winding can proceed at 10 to 50 ft/min. Up to 4000 yds of continuous impregnated tape have been applied to a single part. Tension during winding varies from 3 to 150 lb/linear in. of tape width, depending on material and part configuration. Nylon, now used in most parts, ranges around 11 lb/linear in. of tape width.

When desired thickness has been wound on, it is continually checked with master contour tem-



LAYUP DETAILS show how plies are angled in heat shield to give best reentry performance. Porous material under vacuum vent prevents clogging. Layer of dry, glass cloth facilititates flow of volatiles.

PARTS ARE BAGGED and vacuum cured in an autoclave after winding. See schematic.

Atlas MK-3 ablation shield is bonded to metal or filament-wound understructure

plate, the part is a nearly homogeneous mass. Bulk factor has been reduced considerably over what could be achieved by hand layup.

The part is then bagged over the mandrel for vacuum, autoclave curing. A complete bank of 12 and 8-ft diam autoclaves, used previously for curing B-52 fuel cells, are available on site. There is no heater facility problem. See diagram for cross section of typical layup.

Cure cycles have developed for the various ablation parts produced. Exact cycles are closely guarded since they represent months of expensive research. Cure and post cure are becoming increasingly important in controlling the shrinkage, short and long time, which plagues most plastic parts. In general, 3 to 4 days is required for curing, with a 2 to 3 day post cure. Temperature ranges between 250 and 350°F. This produces parts with the specified 2 to 5 per cent volatile content and stabilizes dimensions. Since curing the resin is an exothermic chemical reaction, care must be taken in the amount and rate of autoclave heat applied. The exothermic property has caused thick test pieces to explode from excess heat.

Vacuum during the cure is maintained at near ½ atmosphere. This is primarily to facilitate the carrying away of volatiles, however, and not to apply pressure. Autoclave pressure varies with the material in use. One resin is cured at 50 psi and another at 200 psi.

After The Cure

After the part is cured and cooled, it is generally trimmed and removed from the mandrel. An hydraulic press is used for removal. Frustum section of the Mk-3 shield is easy to remove, since after first movement it is completely free of the mandrel. Cylindrical sleeve section of the cone is harder to remove. Some draft is built into the mandrel to create a constantly diminishing diameter. This does not solve the problem completely. Since parts are machined on the ID. as well as the O.D. building draft into the mandrel is allowable.

Post curing is usually done after the part is off the mandrel. This is to allow it to stabilize in shrinkage, and facilitate removal of volatites. It also frees the mandrel for winding a new part.

On Mk-3 nose cone parts, I.D. is machined first and the laminate is adhesively bonded over a metal, or filament wound structure. This is to give strength. Machining the O.D. follows. About ½ in. "over wind" is usually applied for machining away. Dimensional tolerance after machining is ±0.003 to 0.005 in. On Discoverer I.D. is not machined.

Parts are ready for shipment to General Electric's MSVD at this point.

Quality Control

Precise record keeping by quality control gives the customer a complete look at the manufacturing cycle of each part. A cycle chart accompanies each part. Raw materials is checked on arrival at Goodrich to see if it complies with the impregnators specifications. End trim of finished parts, is checked for volatile content, resin content, dimensional tolerance, and specific gravity. The actual part is X-rayed 100 per cent to check for voids.

Mechanical testing is not done by Goodrich, but is done by prime contractor GE. End trim is again used in tests. No mechanicals are yet basis for rejection of ablation shields. But, specifications will soon include a requirement of ½ per cent elongation. Tension wound parts usually meet this requirement.

Application

Tape winding has been used on RVX-1, RVX-2 Discoverer Mk-I to Mk-IV, and the Mk-3 nose cone in production and prototype parts. Shapes range from sleeves, to frustums, to hemispheres.

Model parts have also been made in nylon for Minuteman and Titan.

◆

TO REMOVE PART from mandrel, ends are trimmed clean, and an hydraulic press forces part loose. Cylindrical sections are harder to remove. Parting agent is carnuaba wax. End-trim is used in testing.

X-RAY INSPECTION of parts follows machining of I.D. and O.D. Voids are easily detected. Other quality control checks are for volatile content, resin content, and specific gravity.

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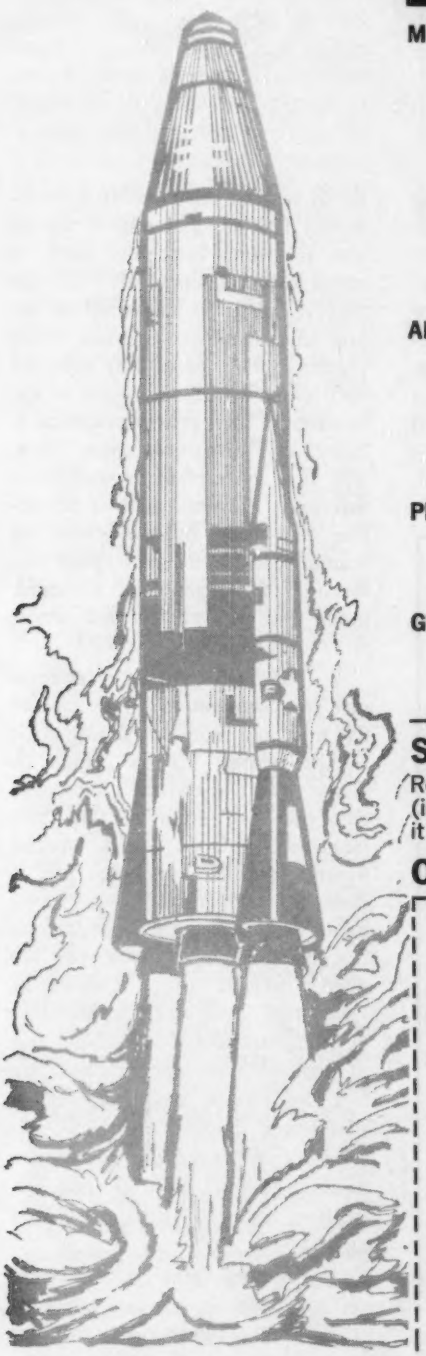

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Optics Can Put Accuracy in Your Design

Line-of-sight instruments have applications from building to aiming missiles

By Harold H. Poett,
Manufacturing Research Engineer,
Missile System Div., Lockheed Aircraft Corp.

A wealth of data is available on optical tooling as related to aircraft structures; little publicity has been given to some unusual applications of vital interest. This article will concern itself chiefly with the latter. The special applications which follow may serve to spark up others and help materialize precise design requirements.

Setting a gyro mounting platform perpendicular to a radar scanner axis within five sec of arc (Fig. 1). This application uses an alignment telescope equipped for autocollimation, a right angle eyepiece and a target mirror; a swinging arm for mirror is mounted on radar scanner. Telescope is fixed on adjustable gyro platform. Scanner is rotated on its shaft approximately 120 deg and mirror-holding arm is swung back and forth to center over telescope. One-half the observed error is corrected in the arm adjustment and one-half in the platform. This process is repeated until coincidence of images in the instrument. This proves perpendicularity of mirror-to-scanner axis, also that gyro plate is normal to this axis. Previous method of setting had been by clinometer on scanner and on gyro platform; leveling of the ship was required, much time was wasted, and results were unsatisfactory.

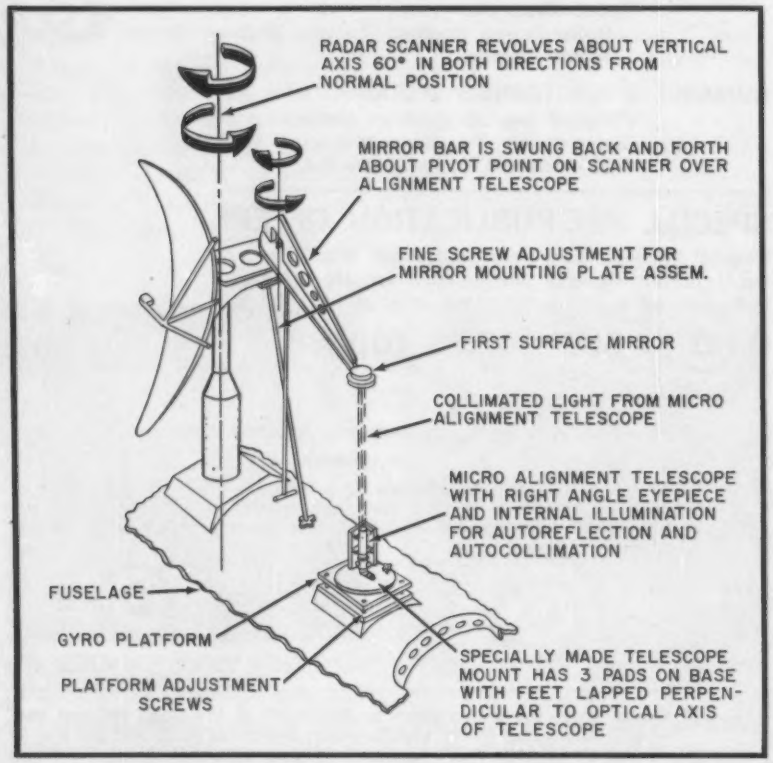
RADAR SCANNER REVOLVES ABOUT VERTICAL AXIS 60° IN BOTH DIRECTIONS FROM NORMAL POSITION
MIRROR BAR IS SWUNG BACK AND FORTH ABOUT PIVOT POINT ON SCANNER OVER ALIGNMENT TELESCOPE
FINE SCREW ADJUSTMENT FOR MIRROR MOUNTING PLATE ASSEM.
FIRST SURFACE MIRROR
COLLIMATED LIGHT FROM MICRO ALIGNMENT TELESCOPE
MICRO ALIGNMENT TELESCOPE WITH RIGHT ANGLE EYEPIECE AND INTERNAL ILLUMINATION FOR AUTOREFLECTION AND AUTOCOLLIMATION
FUSELAGE
GYRO PLATFORM
PLATFORM ADJUSTMENT SCREWS
SPECIALLY MADE TELESCOPE MOUNT HAS 3 PADS ON BASE WITH FEET LAPPED PERPENDICULAR TO OPTICAL AXIS OF TELESCOPE

Fig. 1. Gyro mounting platform is set perpendicular to radar scanner axis, within five sec of arc, by optical equipment.

Setting of missile accelerometer compartment to a tolerance of five min, and recording setting error to the nearest 15 sec. (Fig. 2). Using two alignment telescopes equipped for autoreflection, two magnetic mirrors and special mounts, parallel bars, etc., this is done in less than four hours by two men. Vehicle is leveled optically as first operation and telescopes are aligned to end targets. This establishes two level and parallel lines of sight, parallel to longitudinal axis of vehicle. Telescope brackets are held by bicycle chain and quick disconnect clamps. Precision adjustment on bracket allows accurate leveling to built-in level. Previous method required three men over eight hours.

Setting gyro compartment on a missile to ½ deg tolerance (Fig. 2). This operation takes place

at the same time as the preceding one. Only additional item needed is a gage to position the compartment relative to one of the lines of sight. Operation takes approximately 30 min. Previous method required three men four hr.

Checking torsion stresses on wing surfaces. Using an alignment telescope (or autocollimator) equipped for autoreflection and a mirror, plus applicable mounts, small amounts of angular change are observed. Magnitude of change might be too small to observe on a dial indicator, or too large for a strain gage, or need for accuracy of strain gage and related equipment might not be warranted. (Available autocollimators can read variations of 0.1 sec of arc.)

Bisection of an angle to close tolerances (Fig. 3). A 150-ft aircraft fixture was designed in two parts, each 75 ft long; reference planes of fixtures intersected at the center, at about 10 deg. A one-second theodolite was positioned at the apex of the planes and precise angles and perpendiculars established from this point. At times the theodolite was used as collimator by focusing to infinity and providing illumination. Readings were taken into the theodolite with alignment telescopes positioned on the fixture assembly and also the transit at the bisection of the angle.

Checking deflection of long beams when loads are applied (Fig. 4). This operation requires a precision level with coincidence-type vial and optical micrometer, and a target, or an alignment telescope (with optical micrometer). At close range (6 to 10 ft) a deflection of 0.0005 in. may be observed.

Alignment of rocket-sled rails. Using an alignment telescope and targets, in special mounts, over two miles of rocket sled track was aligned to a tolerance of ± 0.005 in. per 100 ft, and to an 80-mile radius towards Earth's center. Tolerance was non-cumulative. Aljustments to the rails were made every 50 in. These tolerances were mandatory to prevent damaging "G" forces from coming into play.

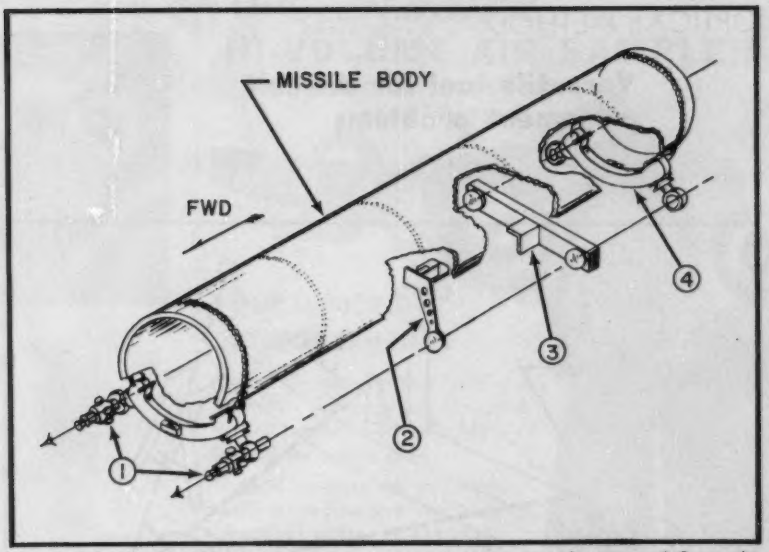

Fig. 2. Missile accelerometer compartment is set to a tolerance of five min, and setting error recorded to nearest 15 sec. (1) Micro alignment telescopes with internal illumination and autoreflection target are held in std. cup bases and spheres. (2) Gyro platform setting tool holds magnetic mirror on R. H. line of sight. Built-in level on tool sets rotation of third axis. (3) Accelerometer compartment is held on parallel bar by toolmakers clamps. Two magnetic first surface mirrors are used for autoreflection; third axis rotation is controlled separately. (4) Aft target bracket is held like FWD assem.

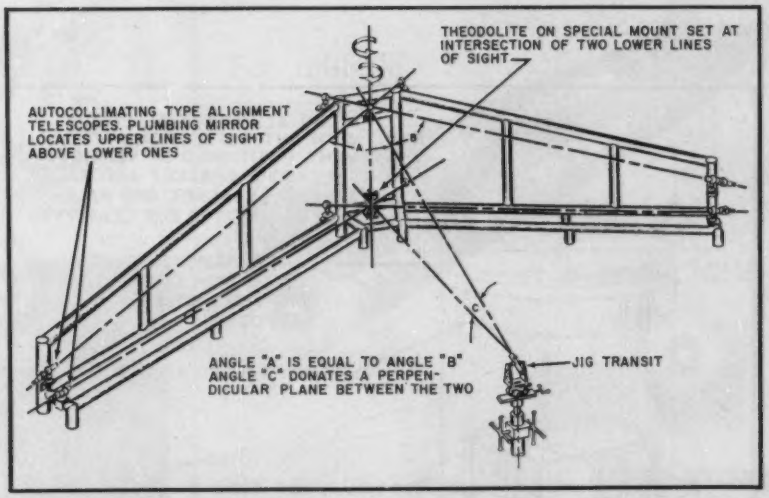
THEODOLITE ON SPECIAL MOUNT SET AT INTERSECTION OF TWO LOWER LINES OF SIGHT
AUTOCOLLIMATING TYPE ALIGNMENT TELESCOPES. PLUMBING MIRROR LOCATES UPPER LINES OF SIGHT ABOVE LOWER ONES
ANGLE "A" IS EQUAL TO ANGLE "B" ANGLE "C" DONATES A PERPENDICULAR PLANE BETWEEN THE TWO
JIG TRANSIT

Fig. 3. To bisect angle between two lines of sight theodolite is collimated parallel to lower scope, plunged, and end target observed. Theodolite is then moved laterally, and kept parallel to coincide with line of sight plane. Vertical axis of theodolite has previously been established as intersection point of lower lines of sight. After establishing theodolite at intersection point, precise angle between two lower lines of sight is read from theodolite, the angle halved, and the transit collimated to the theodolite. Theodolite is then focused to its nearest range, and transit focused to observe projected image from theodolite's illuminated reticle. Transit is then moved laterally so the two observed images coincide. Transit then bisects angle between the lines of sight on the fixture.

Versatile tool for difficult alignment problems

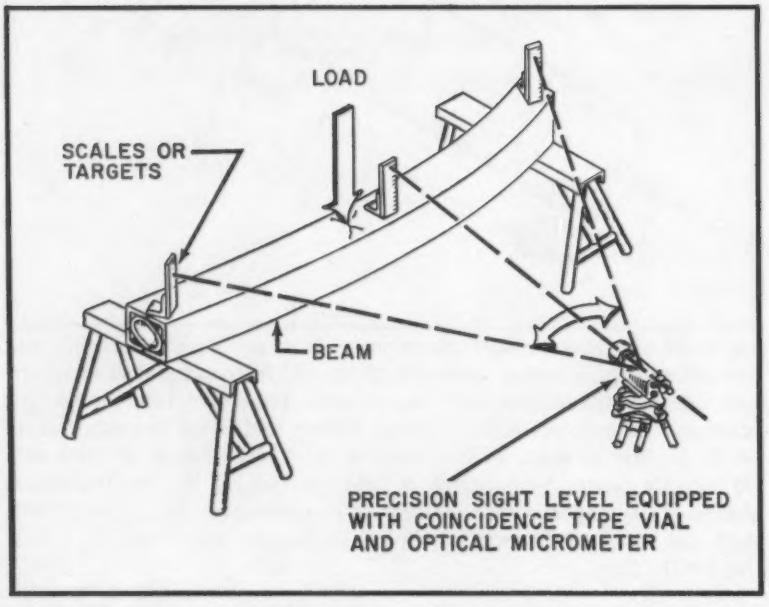

Fig. 4. Beam deflection, under loading, is checked using a precision level.

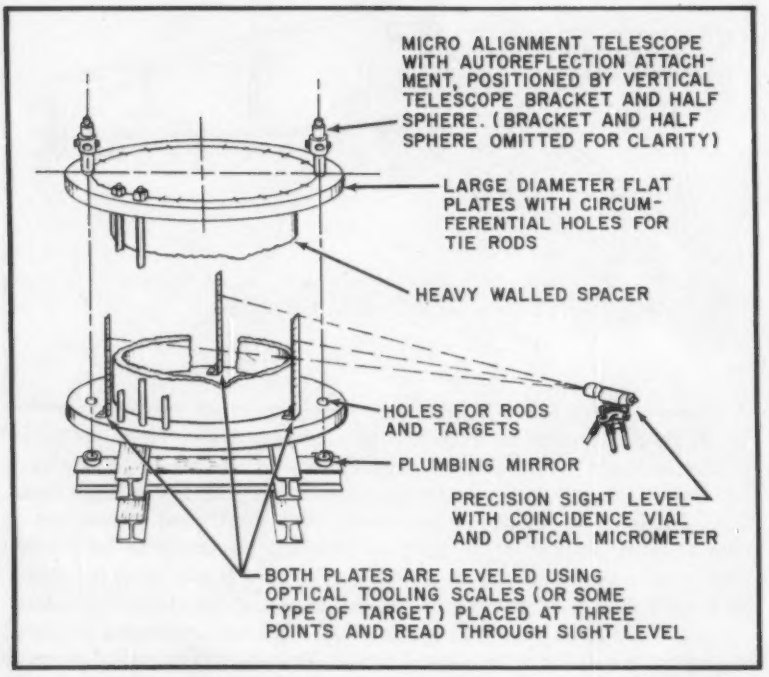
MICRO ALIGNMENT TELESCOPE WITH AUTOREFLECTION ATTACHMENT, POSITIONED BY VERTICAL TELESCOPE BRACKET AND HALF SPHERE. (BRACKET AND HALF SPHERE OMITTED FOR CLARITY)
LARGE DIAMETER FLAT PLATES WITH CIRCUMFERENTIAL HOLES FOR TIE RODS
HEAVY WALLED SPACER
HOLES FOR RODS AND TARGETS
PLUMBING MIRROR
PRECISION SIGHT LEVEL WITH COINCIDENCE VIAL AND OPTICAL MICROMETER
BOTH PLATES ARE LEVELED USING OPTICAL TOOLING SCALES (OR SOME TYPE OF TARGET) PLACED AT THREE POINTS AND READ THROUGH SIGHT LEVEL

Fig. 5. Circumferential holes in two distant plates are aligned axially by optical tooling.

Checking curvature of a radar reflector. A long cylindrical radar reflector had to be held to close tolerances. A jig for building antennas was made using optical tooling; structure of radar antenna was such that alignment target points could be built into it. Alignment telscopes and targets were used in the field for checking and straightening the unit.

Axial alignment of circumferential holes located in two distant plates (Fig. 5). This is done using two alignment telescopes in vertical mounts on the top plate and two plumbing mirrors. Targets are adapted to holes by bushings or other means. Hole axes are aligned and plates are set parallel to each other using precision sight level.

Most aircraft companies have compiled optical tooling manuals for their personnel and for exchange with other companies. These manual's represent considerable effort and expense, therefore, they are not generally available to the public. In some cases, optical tooling manuals may be obtained, in others they may be borrowed for short periods.

Usually, companies selling optical tooling equipment have personnel qualified to evaluate specific problems which may arise for the uninitiated. Optical tooling equipment may also be rented; furthermore, some companies will apply a certain percentage of the rental towards purchase, if the user wishes to buy.

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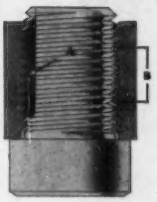
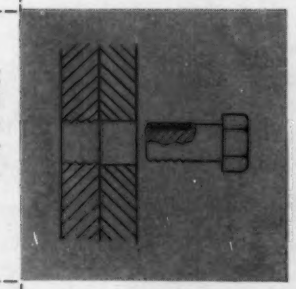
It is vibration resistant because the resilient, reformable insert (A) acts as a wedge between the male and female threads, causing a metal-to-metal drag (B).



LONG-LOK Self-Locking Screws are flush protruded and pass through normal clearance holes with finger pressure. No special clearance holes are required.



LONG-LOK Self-Locking Screws save time and money because they eliminate safety wire (and head drilling), and lock washers. They also save weight.

LONG-LOK Self-Locking Screws are available for aircraft, missile and commercial applications. They meet MIL-F-18240 Specifications and can be head marked for self-lock identification.

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Component Testing Makes Atlas Reliable

Wyle Labs use three data-recording systems in checking reliability to 99.9999 . . . per cent

by William W. Holbrook
Wyle Laboratories, El Segundo, Calif.

When an Atlas missile is launched and it fulfills its mission, "almost perfect" reliability scores. This means that some 300,000 parts making up the missile have functioned with a reliability of 99.999996 per cent. Wyle Laboratories, El Segundo, Calif., contributes to such reliability by testing electronic, pneumatic, mechanical, and hydraulic components for most missiles.

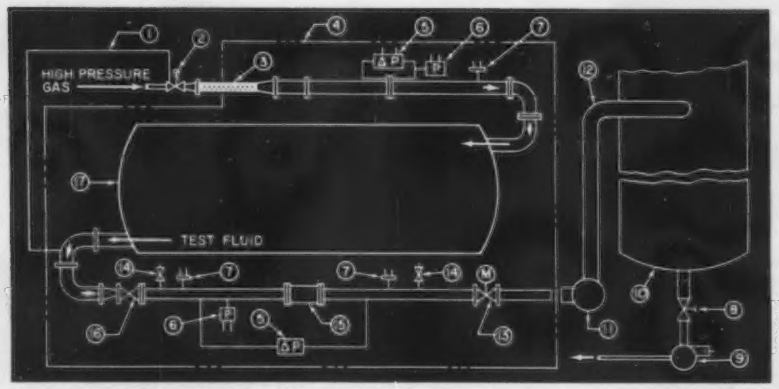
To meet the wide variety of test programs in which the company participates, the instrumentation department operates three different types of instrument systems: a central instrumentation room, mobile consoles, and a motorized instrument trailer.

Central Instrument Room

This installation consists of 14 ElectroniK recorders: 10 two-pen, two-second strip chart recorders; two single-pen, one-second strip chart recorders; and two single-pen, ¼-second strip chart recorders. An auxiliary Sanborn and Honeywell Visicorder console is also used. This room is often used in conjunction with a high-pressure helium system for testing liquid oxygen tank pressurization regulators.

To test the liquid oxygen pressure regulators of the Atlas, a system is used simulating the missile installation. System includes a water tank eight feet in diam and fifty-five feet high. Water flow out of tank is programmed to simulate ullage* change in the missile; actual Atlas missile ducting is used between regulator and tank. A heat exchanger, upstream of the regulator, conditions helium from —320°F to 500°F and provides pressures from 0 to 4000 psi to regulator inlet.

Helium is allowed to flow into water tank much as it would flow into the liquid oxygen tank during missile flight. The helium is used to provide a non-reactive constant pressure "cover" to the oxygen. Temperature and pressure are critical. Tank pressure, maintained by regulator, must be accurate within about one per cent. No commercial system was available to satisfy this requirement. The problem was solved by using a dead-weight tester as a calibration standard, and a recording system with excellent repeatability, resolution, and long-term stability. A one-second ElectroniK strip chart recorder was selected for this application. A special bridge circuit,



GRAVIMETRIC FLOW-CALIBRATION system is used for testing airborne, turbine-type, liquid oxygen flowmeter.

**Loss in weight and/or shift in balance caused by a large amount of a liquid or gas being removed from a container.*

designed for this instrument, allowed use of a switch to select several ranges of suppression and maintain a very narrow fixed-span. This recorder, used in conjunction with hand-picked pressure transducers, has a repeatability over one-tenth of one per cent. The recorder/transducer combination has proved very satisfactory for this type of measurement.

Entire system is calibrated as a unit prior to testing, and nonlinearities are taken into account when reducing the data. The expanded scale and 11-in. chart paper of the recorder, provides good readability.

The central instrumentation room is also wired to various test stations for transducer signals and power; junction boxes incorporate event marker and chart drive programming. Thus, test conditions are recorded centrally while specimens at various test stations are subjected to vibration, acceleration, altitude, and other natural and induced environments. Using remote programming, a test engineer can record the various channels independently as functions of importance occur.

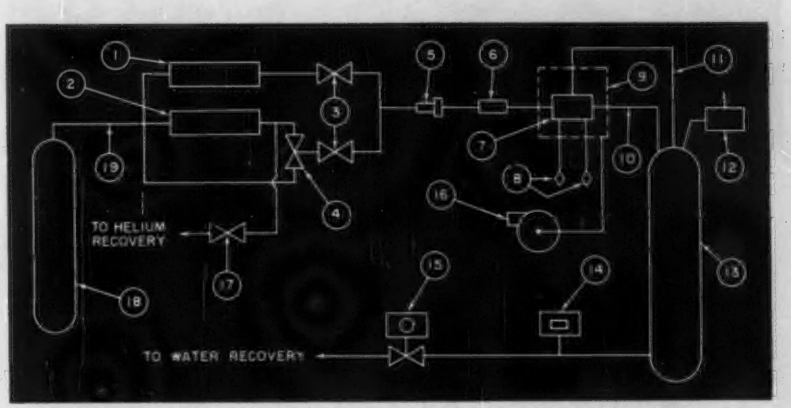
Portable Consoles:

Each console is equipped with a Visicorder and a master control and calibration panel. The master control unit has provisions for ten plug-in boxes. By selecting the proper plug-in and transducing element, the test engineer can measure pressure, temperature, speed, torque, voltage, current, etc . . . This system requires no matching or external wiring in the setups for measurements, and has thus reduced setup time over fifty per cent.

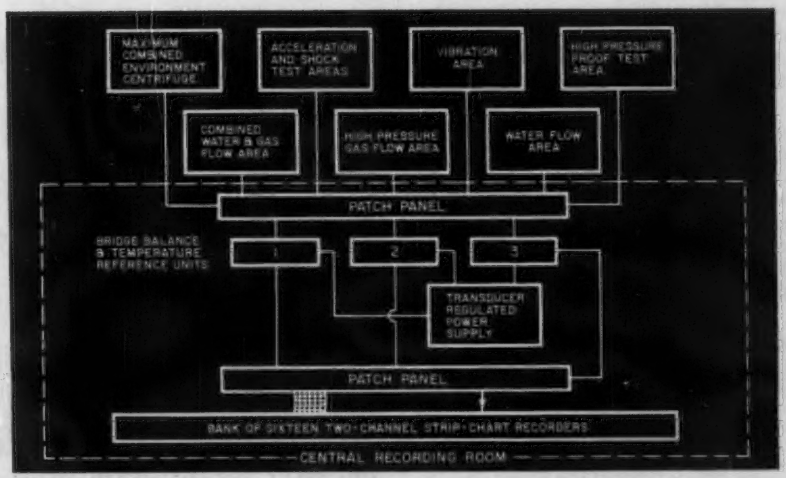
Portable consoles are used in a variety of applications. Each Visicorder on console has eight available channels. Most test programs include several pressure measurements, taken by strain gage, variable reluctance, or potentiometer-type transducers. The console can handle up to six different pressure measurements using any of these transducers. Each test program may include several temperature measurements where the choice of transducer is either a thermo-couple or any type of resistance thermometer. The recording console can handle up to six different temperature measurements. Temperatures and pressures are normally intermixed with measurements of torque, strain, and other physical conditions.

The problem of checking a pilot-operated solenoid valve for actuation time provides a good example of the versatility of these consoles. This valve is constructed so that mechanical coupling to the poppet is impossible. Because of the system conditions, it was not feasible to determine actuation time by measuring such things as flow, pressure, and actuating current. In this case, a contact microphone was connected to the body of the valve and the noise generated by poppet movement was recorded on one channel of the Visicorder console.

Another example of the console's use is in checking the coasting characteristics of an aircraft cabin pressurization valve assembly with a total assembly movement of 0.8 deg rotation. Here an inductive potentiometer was connected to a Visicorder channel. This combination was then calibrated on a dividing head, and connected to the valve assembly for the test. Motion of potentiometer was recorded as motion of the valve assembly. *continued on next page*



LIQUID OXYGEN test-setup schematic is shown for the pressure regulator used in the Atlas.



BLOCK DIAGRAM is shown of Wyle Laboratories' centralized instrumentation system.

"Information Center" for Roebling Aircord

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Trailer system used by Norco at cryogenic test-site

Instrument Trailer

This unit contains a combination of recording equipment including both strip chart recorders and Visicorders. Strip chart recorders are of the variable span and variable suppression type, used principally for recording very low temperatures. The millivolt-per-degree output of copper constantan thermocouples used at these low temperatures is much smaller than that obtained at ambient temperature and above. By using variable-span and variable-suppression recorders, it is possible to calibrate the instrument to a narrow span of temperatures, then to suppress this span within the limits of ±50 millivolts, so that only the area of interest is recorded.

The Norco Cryogenic Facility, uses the trailer, in low-temperature testing of components for large ballistic missiles. Special techniques are used for measuring flow, pressure, temperature, etc., in this environment. Generally, turbine-type meters are used to measure flow. Output of these flowmeters is an alternating current whose frequency is proportional to the flow rate. Several types of pulse rate converters are available to convert this signal to d-c signal.

Pressures are measured with transducers compatible with liquid oxygen. This means that all "0" rings and seals must be made of Teflon or similar fluorocarbon resins. Each pressure transducer installation must be considered as a special case and the unit mounted in such a way that either the diaphragm or internal mechansim will come in contact only with gaseous oxygen or nitrogen. For particularly high response, the transducer must be a flush-type diaphragm calibrated at low temperatures.

A typical test program using the instrumentation trailer concerns an airborne turbine-type meter for measuring liquid oxygen flow. The system for this test uses a 4100-gal tank mounted on a mechanical scale. An electrical switching box is adapted to the scale in such a manner that it senses the balance of the scale. The following conditions are recorded as test data during a calibration test run:

- Temperature upstream of the meter
- Pressure upstream of the meter

CENTRAL INSTRUMENTATION ROOM can record up to 20 channels of test data on Minneapolis-Honeywell recorders.

PORTABLE VISICORDER console is used for testing components in sites removed from central instrumentation room.

• Tank temperature in two locations

• Orifice temperature on the 4100-gal tank pressurization system

Here's How The System Works:

The 4100-gal liquid oxygen tank is filled. A counterpoise weight on the scale is set to balance at capacity less 15 per cent. Tank is then pressurized and a flow-control valve, downstream of the meter, is opened to establish a given flow rate. When tank weight reaches capacity less 15 per cent, the scale will balance. This triggers an electronic counter which starts the totalization of the pulses out of the turbine type flow meter.

Counterpoise weight is then set at capacity less 65 per cent. When tank weight reaches that of the second counterpoise weight setting, the scale will again balance, stopping the electronic counter. Flow meter gives total weight change in test run. Total gallons can then be computed by taking into account the upstream temperature. Thus, a calibration factor for the flowmeter is obtained in the form of counts per gallon at a given flow rate.

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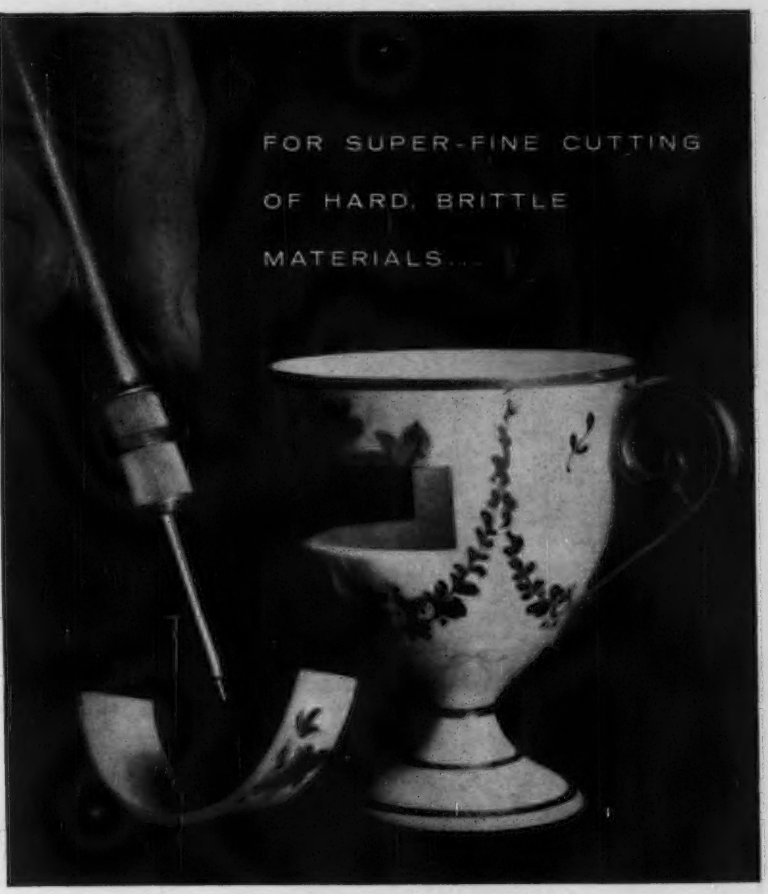

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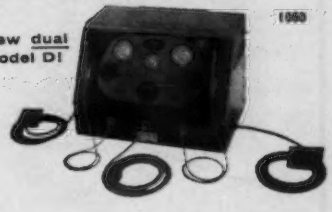
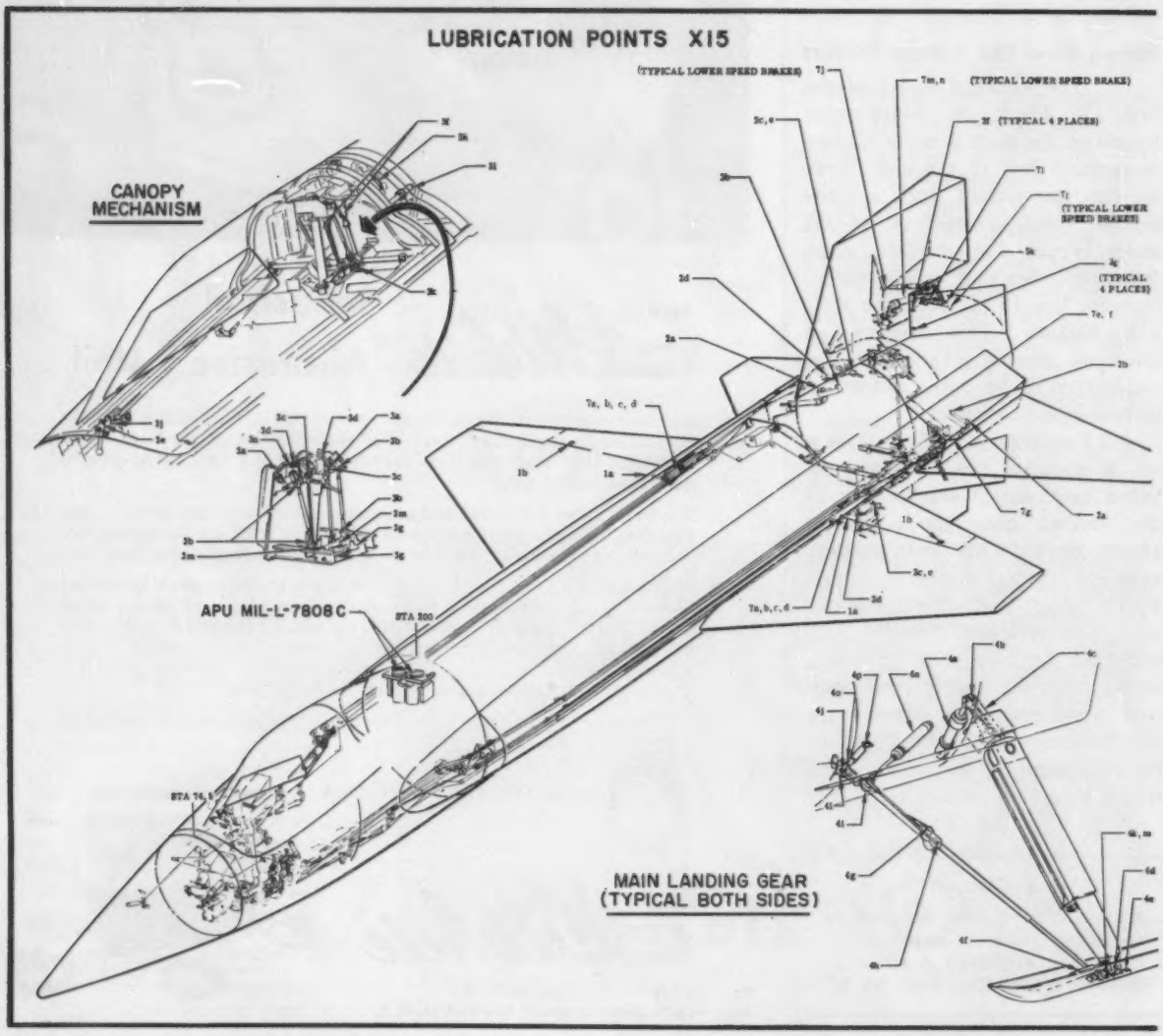


S. S. WHITE INDUSTRIAL DIVISION
Dept. 18A, 10 East 40th Street, New York 16, N. Y.

Lubricating X-15's Hot Bearings

Commercially available grease meets re-entry requirements on control surface bearings; Maintains lubricity under loads of 26,000 psi at 500°F

by F. R. Watson, Special Engineer, **and A. L. Ludwig,** Senior Engineer, Shell Oil Co.



The lubricant used on bearings in X-15's control system must maintain lubricity through at least one max-performance flight. This sounds like a small order. But, in some cases, bearings are only inches away from skins that glow from reentry heat. To stay on the safe side, hi-temp-resistant grease is used throughout the control system.

At the outset, actual temperatures the various areas of the X-15 would encounter during flight were not known. Calculations determined from flight profiles, however, established close approximations. Based on these calculations, test programs were set up to choose a grease with optimum lubricating characteristics. Evaluation of greases was undertaken in a specially constructed North American Aviation (NAA) test facility by the company's Material and Process Lab.

Test Procedure

Bearings were exposed in MAA test machines. Evaluation was done at bearing-load levels of 26,000 psi, and at 400 to 550°F. Procedure was to operate the bearings with grease, relubricate the bearings every 500 operating cycles and run until failure, or 20,000 cycles. The number of test cycles is regarded as an arbitrary figure since a bearing that has operated for 20,000 cycles without galling or

ITEM NO.	LUBRICATION POINT	BEARING TYPE	LUBRICANT	LUBE. INTERVAL
	WING			
1a	Wing flap inboard hinge fitting	Plain spherical	Aeroshell 5A (Shell Oil Co.)	Each flight
1b	Wing flap outboard hinge fitting	Plain spherical	"	Each flight
	EMPENNAGE			
2a	Horiz. stabilizer outboard hinge pin	Plain spherical	"	Each flight
2b	Horiz. stabilizer inboard hinge pin	Plain spherical	"	Each flight
2c	Vert. stabilizer to actuator attach	Sleeve	"	Each flight
2d	Vert. stabilizer to actuator attach	Sleeve	"	Each flight
2e	Vert. stabilizer hinge pin	Plain spherical	"	Each flight
2f	Upper dive brake hinge pin	Plain spherical	"	Each flight
2g	Lower dive brake hinge pin	Plain spherical	"	Each flight
	COCKPIT ENCLOSURE			
3a	Canopy drag latch bell crank	Sleeve (oilite)	MIL-L-7870	25 hr
3b	Canopy drag latch bell crank attach	Plain spherical	MIL-L-3278	25 hr
3c	Canopy mechanism clevis	Sleeve	MIL-L-7870	25 hr
3d	Canopy remover bell crank	Sleeve	MIL-L-7870	25 hr
3e	Canopy manual release handle	Sleeve	MIL-L-7870	25 hr
3f	Pneumatic balance lower support fitting	Sliding	MIL-G-3278	25 hr
3g	Pneumatic balance upper support fitting	Pin	MIL-G-3278	25 hr
3h	Canopy mechanism bungee	Sleeve	MIL-L-7870	25 hr
3i	Fuselage canted station 77.529 forward latch retainer fitting	Sleeve	MIL-G-3278	25 hr
3j	Canopy external operating rod	Sleeve Slide	MIL-L-7870 MIL-G-3278	25 hr 25 hr
3k	Canopy torque tube retainer	Journal	MIL-G-3278	25 hr
3l	Canopy dynamic damper bungee	Internal surfaces	MIL-L-7870	25 hr
3m	Canopy drag latch and ejection gun bell crank	Sleeve	MIL-L-7870	25 hr
3n	Canopy remover bell crank support	Sleeve	MIL-L-7870	25 hr
	MAIN LANDING GEAR			
4a	Strut assembly	Plain spherical Felt wiper	MIL-G-3278 MIL-O-5606	Each flight Each flight
4b	Shock absorber attaching pin	Plain spherical (in strut assembly)	MIL-G-3278	Each flight
4c	Strut bell crank	Bushing (2)	MIL-G-3278	Each flight
4d	Skid universal pin	Sleeve	MIL-G-3278	Each flight
4e	Skid trunnion fitting	Sleeve	MIL-G-3278	Each flight
4f	Skid positioning bungee	Plain spherical	MIL-G-3278	Each flight
4g	Drag brace upper link assembly	Sleeve	MIL-G-3278	Each flight
4h	Drag brace pivot pin retainer	Sliding surface	MIL-G-3278	Each flight
4i	Drag brace sequence hook	Sleeve	MIL-G-3278	Each flight
4j	Drag brace upper attaching eyebolt	Plain spherical and pin	MIL-G-3278	Each flight
4k	Drag brace lower attaching eyebolt	Sleeve	MIL-G-3278	Each flight
4l	Uplock hook	Plain spherical	MIL-L-6085	25 hr
4m	Drag brace lower attaching fitting	Sleeve	MIL-G-3278	Each flight
4n	Snubber cylinder	Plain spherical	MIL-G-3278	Each flight
4o	Uplock bungee cylinder	Plain spherical	MIL-L-6085	25 hr
4p	Sequence rollers	Sleeve	MIL-L-6085	25 hr
	SURFACE CONTROLS			
7a	Flap control mechanism	Sleeve	Aeroshell 5A (Shell Oil Co.)	Each flight
7b	Flap actuator mechanism	Sleeve	"	Each flight
7c	Flap control toggle	Sleeve	"	Each flight
7d	Flap actuator rod end	Plain spherical	"	Each flight
7e	Yaw hydraulic flight control actuator gimbal	Sleeve	"	On assembly
7f	Yaw hydraulic flight control actuator rod end	Plain spherical	"	Each flight
7g	Horiz. stabilizer actuator rod	Plain spherical	"	Each flight
7h	Horiz. stabilizer actuator cylinder	Plain spherical	"	Each flight
7i	Speed brake attach trunnion	Sleeve	"	Each flight
7j	Speed brake attach rod end	Plain spherical	"	Each flight
7k	Speed brake crank LH pin assembly	Sleeve	"	Each flight
7l	Speed brake crank lower pin assembly	Sleeve	"	Each flight
7m	Speed brake hydraulic control actuator rod end	Plain spherical	"	Each flight
7n	Speed brake hydraulic control actuator head assembly	Plain spherical	"	Each flight

How long can lubrication be expected to last on a re-entry vehicle?

scoring might just as easily be run for 40,000 cycles, provided the grease continued to lubricate.

In the test, a bearing or lubricant failure showed up as an increase in friction. This caused a signal to be automatically relayed through a special electrical control unit. The control stopped the test machine at first sign of failure, so that an unsuitable grease had a shorter cycle life than an acceptable grease. Thus, galling was stopped in time to prevent gross seizure of the bearing.

Of the 24 greases tested, only five completed the required number of test cycles. Of the five, only one was a commercially available product.

The grease is known as AeroShell Grease 5A, a patented sodium-soap, mineral-oil combination. At conclusion of 20,000 cycles of operation and exposure to 400 to 500°F, the grease and the bearings it lubricated were still in satisfactory condition. Friction had not increased to any serious degree and relubrication was possible since the zerk fittings were quite clear.

Bearing Operation

This grease is, therefore, used in about 50 separate bearings in components of four main systems —flaps, speed brakes, and horizontal and vertical stabilizers. All are located in the aft fuselage of X-15. Bearings are used mainly in primary control hinges which permit control of the aircraft—and in hydraulic cylinders which actuate these hinges. The hydraulic cylinders are servo-actuated by means of standard pilot-controlled linkage systems.

Cycling of these bearings is such that in normal operation there is only a few degrees of movement for slight control changes. During extreme maneuvers, the surfaces may deflect as high as 30 or 40 deg. Speed brakes have a larger degree of movement than other systems, but will not require nearly as many movements during flight.

Total loads on hinge bearings (which run to 1¼-in. bore size) are upwards of 50,000 lb. This is a bearing pressure of 35,000 psi, an unheard-of figure in some industries, but not uncommon with aircraft.

All bearings are located on the power side of actuators, where moving friction is not a serious problem. Plain spherical and sleeve bearings were selected instead of the anti-friction type since there was not so much concern with rotation, as there was with the small oscillations required to maintain control of the aircraft.

Bearings and pins are considered as a single unit. The bearing is commercially available in most cases, except that closer tolerances and slightly better precision in manufacture are required. The pin which turns against the bearing is a specially-made part of high-strength steel. It is chrome plated and ground to a surface finish of 16 microinches or less.

Materials of Construction

Both the plain spherical balls and the plain bushings are made of AISI 52100 steel. Plain spherical bearings are used where there might be a problem in assembling the part, or in those cases where the bearing might misalign during some portion of its movement. Plain sleeve bearings are used where there is no possibility of structure misalignment.

Most of the X-15 control bearings are charged with the high temperature grease by means of a regular air-driven pressure unit of 150 psi capacity, delivering about 60 psi at the nozzle. For rod-end bearings, a 125 psi air-pressure system is used. Clearances determine how much pressure is required to force grease into bearings—a close-clearance bearing naturally will require a higher pressure and take longer to pack.

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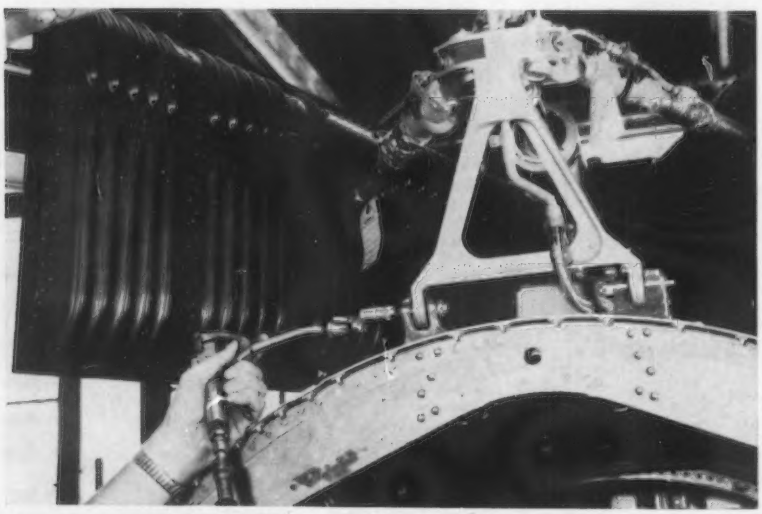

UPPER SPEED BRAKE assembly of X-15, showing location of control hinges. Thermal expansion plus airloads in flight will result in a 2-in. deflection about the hinge points.

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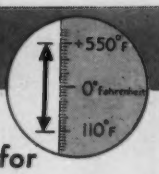

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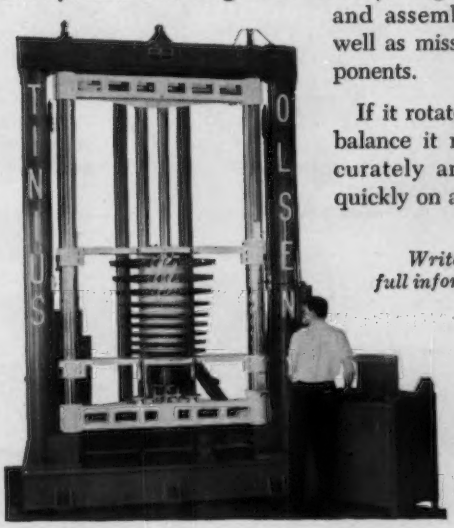
141 ALBERTSON AVENUE · ALBERTSON, L. I., N. Y. · PIONEER 1-4333

Circle 31 on Inquiry Card

BALANCING JET ENGINES ?

Tinius Olsen offers the most complete line of static *and* dynamic balancing machines for jet engine stages and assemblies, as well as missile components.



If it rotates, you'll balance it more accurately and more quickly on an Olsen.

Write for full information.

TINIUS OLSEN
Testing Machine Co.
2210 Easton Rd. • Willow Grove, Pa.

Circle 33 on Inquiry Card

Worth Asking For

Competition

32-page illustrated booklet, "The Story of Competition in the American Market." *E. I. du Pont de Nemours and Co.*

Circle 50 on postcard for more data

Jet Engine Testing

Brochure, "Digital Instrumentation For Jet Engine Testing" includes rundown of typical systems. *Berkeley Div., Beckman Instruments.*

Circle 51 on postcard for more data

Thermal Insulation

Thermal insulations for commercial and industrial requirements, in applications ranging from —400°F, described in 54-page catalog. *Johns-Manville Sales Corp.*

Circle 52 on postcard for more data

Metal-Etch Resist

Metal-Etch Resist, control material for metals-working industries, using etching, photo milling, or plating techniques, described in pamphlet. *Eastman Kodak Co.*

Circle 53 on postcard for more data

MIG Gyros

Bulletin on miniature floated rate integrating gyros includes specs, uses. *Kearfott Div., General Precision, Inc.*

Circle 54 on postcard for more data

Molybdenum

Constitution Diagrams provide condensed data and selected references on binary and more complex diagrams pertaining to molybdenum. *Climax Molybdenum Co.*

Circle 55 on postcard for more data

Plastics

Structural plastics for corrosive and abrasive service described; also screen assemblies. *CTL, Div. of Studebaker-Packard.*

Circle 56 on postcard for more data

Fotoceram Wafers

Bulletin on Fotoceram micromodule wafers. *Receiver Bulb Sales Dept., Corning Glass Works.*

Circle 57 on postcard for more data

Tube Forming

Aircraft engineering bulletin covers fabrication of tight bend tubes. *Aeroquip Corp.*

Circle 58 on postcard for more data

Aluminum Facts

Alcoa Structural Handbook (1960). *Aluminum Co. of America.*

Circle 59 on postcard for more data

Hi-Temp Fasteners

Catalog 286 shows fasteners for elevated temperature. *Mercury Air Parts Co.*

Circle 60 on postcard for more data

Business Trends

Graphs show factors in business trends since 1835. *Ex-Cell-O Corp.*

Circle 61 on postcard for more data

Missile Ground Support

Photos, description of ground support equipment for Redstone, Jupiter, and other missiles. *Designers for Industry Inc.*

Circle 62 on postcard for more data

Garrett Progress

Brochure, "Career Opportunities" available to those interested in research and manufacturing projects of the firm. *Garrett Corp.*

Circle 63 on postcard for more data

Rocket Propellants

Performance data for 12 possible rocket propellant combinations—each involving the use of concentrated hydrogen peroxide—set forth in chart. *Becco Chemical Div., Food Machinery and Chemical Corp.*

Circle 64 on postcard for more data

Atomic Instrument Catalog

Catalog of atomic instruments, systems and accessories. *Baird-Atomic Inc.*

Circle 65 on postcard for more data

Reactive Metals

Material specs for reactive metal castings covers titanium, zirconium and their alloys. Also, a data sheet on casting furnace capabilities of reactive metals. *Oregon Metallurgical Corp.*

Circle 66 on postcard for more data

Space Chambers

Brochure describes features, capabilities of walk-in space chambers. *Tenney Engineering Inc.*

Circle 67 on postcard for more data

Machine Tool Control

Numerical control positioning system described. *Hughes Products.*

Circle 68 on postcard for more data

Fuel Pumping

Application of sealless "canned" pumps for leakproof pumping of fuels and oxidizers for missile and jet engines is discussed in 4-page technical bulletin. *Chempump Div., Fostoria Corp.*

Circle 69 on postcard for more data

Word Indicator Lights

Catalog 159C describes the large legend Roto-Tellite line. *Master Specialties Co.*

Circle 70 on postcard for more data

Propellant Loading

Data Sheet MED 2, describes propellant loading programmer. *Missile Equipment Div., Minneapolis-Honeywell Regulator Co.*

Circle 71 on postcard for more data

Pyrometer

Bulletin shows portable indicating pyrometer which measures temperatures between —40°F and 200°F. *Illinois Testing Labs.*

Circle 72 on postcard for more data

Electro-Mechanical Equipment

Catalog describes firm's electromechanical, mechanical and electronic equipment available to the aircraft, missile and related fields. *Airborne Accessories Corp.*

Circle 73 on postcard for more data

Plasma-Jet Coatings

Six-page illustrated brochure on plasma-jet coatings, metal and ceramic spraying, and other hard-facing services for industry. *Cleveland Hard Facing Inc.*

Circle 74 on postcard for more data

Space Shots

Space calendar lists all U. S. and foreign space shots and supplies a log for similar activities in 1960. *Avion Div., ACF Industries Inc.*

Circle 75 on postcard for more data

Flame-Retardant Laminate

Bulletin describes Fireban-X for aircraft structural parts. *Taylor Fibre Co.*

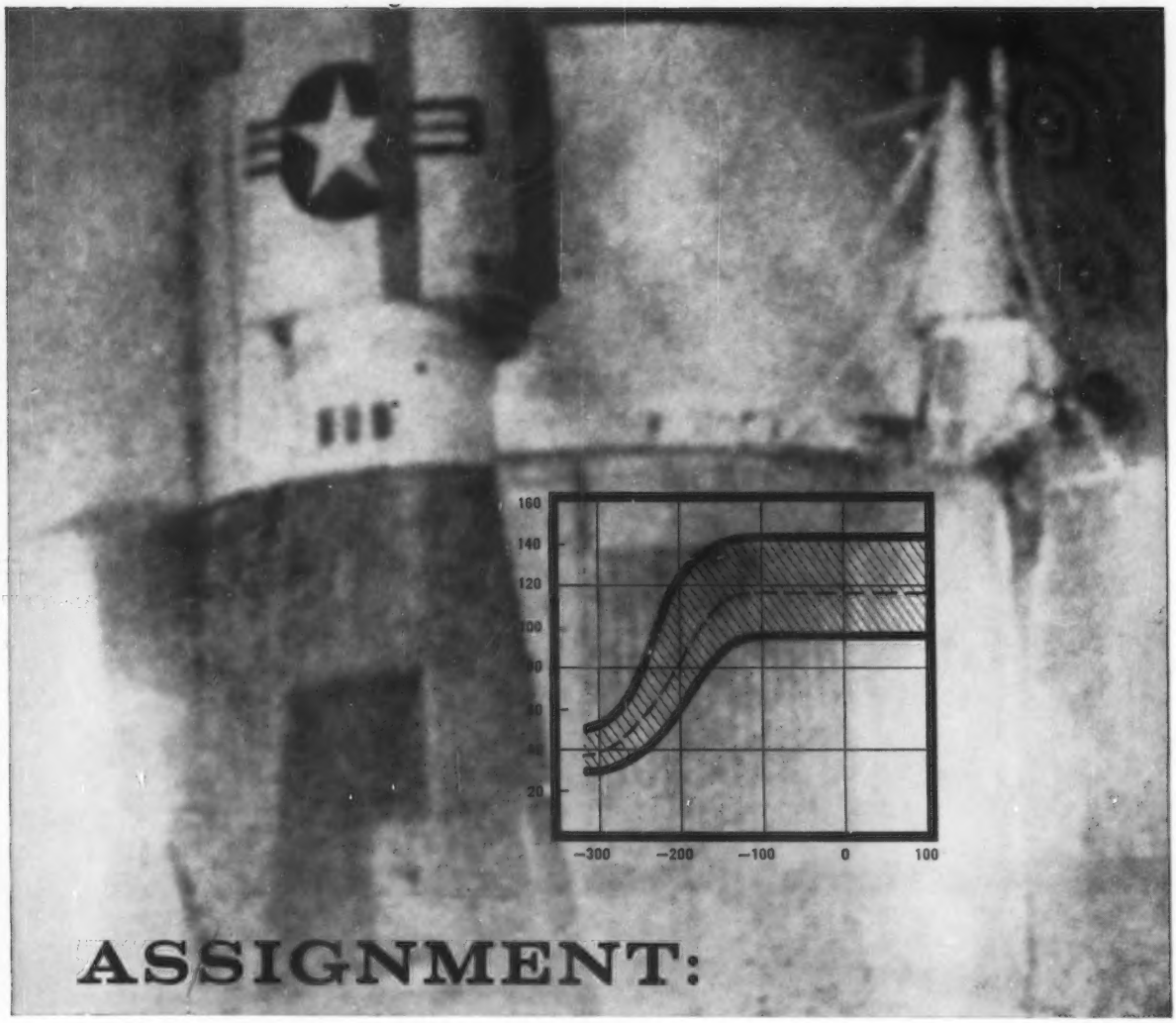
Circle 76 on postcard for more data

Testing Facilities

Brochure on environmental, qualification and reliability testing facilities. *Horkey-Moore Associates.*

Circle 77 on postcard for more data

For the hottest spots
in missiles
ctl



ASSIGNMENT:

CRYOGENICS

How Lukens *Application Research* helps you find the right steel plate for the job

If your assignment is designing equipment for extreme low temperature service—our Application Engineering staff can help you. They research problems of every description from the design stage right through to how the equipment has performed for years after its installation.

Missile components and liquefied gas tanks would be dangerously susceptible to cracking if made from ordinary steel. Seeking economical metals for such applications, Lukens engineers began years ago to watch the performance of nickel bearing alloys in a variety of low temperature equipment. Result: a broad understanding of metal behavior at various low temperature levels.

Examples: In the storage of liquefied oxygen, a tank of *Nine Nickel steel* provided more than eight years of trouble-free performance. Suitable to minus 320°F. service the steel showed no signs of cracking when removed for inspection. In frigid chambers for testing high altitude aircraft, *2½ percent nickel steel* is standing up well under pressures as high as 7,000,000 pounds. And in arctic locomotives operating at temperatures to minus 50°F. on rugged mountain roadbeds, main structures of *Lukens "T-1" Steel* have required no maintenance whatsoever.

Lukens Application Engineers know these cases . . . plus many more. *If your assignment is cryogenics, why not let it be our assignment, too?* Contact Manager, Application Engineering, L-20 Services Building, Lukens Steel Co., Coatesville, Pa.

Helping Industry Choose Steels That Fit The Job

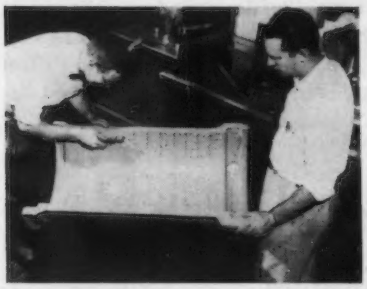
LUKENS®

ASK FOR LUKENS NINE NICKEL STEEL BULLETIN

New Materials

Plastic Jet Parts

Plastic parts for major jet engine components are being investigated for the Navy. Polyester laminate reinforced with glass cloth has

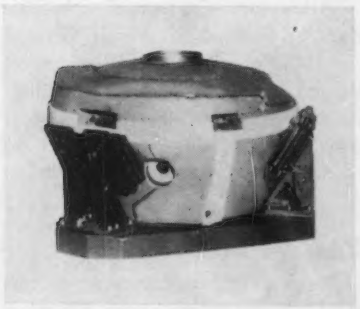


been made into a compressor housing and run for 150 hr in a J-34-WE-36 engine. A high-pressure molding technique was used to make the part. There was no loss in power throughout the 150 hr test. **Westinghouse Electric Corp.**

Circle 78 on postcard for more data

Lighter Insulation

Custom-molded fiberglass insulation reduces the cool air requirements for a precision astro-tracker

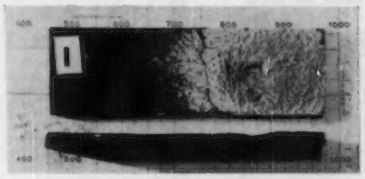


by ⅔. This molded insulation replaced a sewn blanket-type asssembly which weighed about 4½ lb, and which put a critical requirement on the cooling equipment. The new insulation weighs only 2¼ lb. It comes in several large sections. An integrally-applied glass cloth jacket is placed over the insulation. The cloth is coated with high-temperature synthetic rubber. Insulation withstands continuous temperatures up to 300 F. **Fibrous Glass Products Inc.**

Circle 79 on postcard for more data

Heat Resistant Sheet

Resin-bonded quartz sheet, combination of reinforced plastics and ceramics, possesses high heat-resistance. Finely-divided particles



of fused quartz are bonded together with Cordo Pyropreg resin. A small percentage of glass or other fibers is included. Exceptionally low ablation loss under extreme conditions is attributable in large part to the quartz with melting point above 3100°F. Picture shows the sheet after test in the 5500°F blast of an O-H rocket motor for sixty sec. It was dropped in cold water a few sec. after cut off. **Cordo Chemical Corp.**

Circle 80 on postcard for more data

Improved Viton

New breed of Viton fluoro-elastomer claims better temperature resistance and immunity to certain oils and chemicals. From 500 to 600°F retention of hardness and elongation are better than Vitons now available. Resistance to red fuming nitric acid is good. **E. I. du Pont de Nemours & Co.**

Circle 81 on postcard for more data

Hi-Temp Laminate

Paper-base laminated plastic combines flame-retardance with excellent mechanical properties. Known as Fireban X, the material is a Grade X laminate with a special phenolic resin. **Taylor Fibre Co.**

Circle 82 on postcard for more data

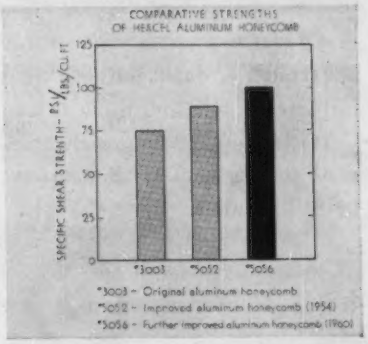
Bonding Fluorocarbons

Reliable Teflon and Kel-F bonds can be obtained with elastomeric adhesives if parts are treated with FSP (Fluorocarbon Surface Preparation). Process consists of 3 steps: (1) vapor blast, (2) chemical etch, (3) coating with high temperature polymer. With double lap-shear specimens, ultimate shear ran to 980 psi at 275°F for Teflon-to-stainless bonds. Kel-F-to-stainless bonds were lower at 850 psi. **R. F. Plastics Co.**

Circle 83 on postcard for more data

Stronger Honeycomb

Aluminum honeycomb of 5056 alloy is claimed 15 per cent stronger than any other comparable material. Addition of magnesium has



made the strength jump possible. Cell diameters range from ⅛ to ⅜ in. and foil gages from 0.001 to 0.002 in. **Hexcel Products Inc.**

Circle 84 on postcard for more data

BERYLLIUM is available now. It is being used in increasing quantities for aircraft/missile, nuclear and instrument applications.

With 25 years experience in producing beryllium copper alloy mill products, The Beryllium Corporation now offers fabricated beryllium metal.

Our experienced research and sales engineering departments invite inquiries for production or development interest in *beryllium*. Write for information or assistance. Our engineers will gladly work with you.

BERYLCO® **THE BERYLLIUM CORPORATION**

P.O. Box 1462, Reading, Pennsylvania

Circle 36 on Inquiry Card

New Materials

Teflon Heat-Shield

Teflon, less than ⅓-in. thick, is being studied to protect base metals from reentry heat. This thin layer could provide protection for 2 min, without raising metal temperature much beyond room temperature. Teflon sublimes and absorbs great heats. Underlying plastic is highly insulating. Vaporization is limited to thin surface layer. **E. I. du Pont de Nemours & Co.**

Circle 85 on postcard for more data

Sublimation Compound

A thin coat of a paint-like compound called Thermo-lag can keep space vehicle interiors at 90°F despite friction heat of more than 2000°F on the outside. The compound was used on a Little Joe capsule occupied by a Rhesus monkey. Thermo-lag was sprayed on the outside of the Little Joe capsule. It dissipated heat and controlled temperature by sublimation. **Emerson Electric.**

Circle 86 on postcard for more data

Boron-Free Wire

Aluminum wire coated with "Durock," a boron-free ceramic, is rated for 1000°F operation. Wire can be wound around mandrel five times its own diameter. **Technical Industries Corp.**

Circle 87 on postcard for more data

Porous Metal

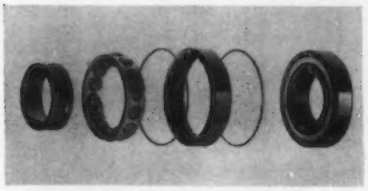
Poroloy CS, wound-wire porous metal, extends range of filtration and non-filtration applications for aircraft. It is wound by a high-precision wire-winding process into hollow cylinders or cones. **Bendix Aviation Corp.**

Circle 88 on postcard for more data

New Parts and Components

Precision Bearings

Full-depth, symmetrical raceways with no loading slots permit these bearings to carry thrust loads from either direction. One-piece,

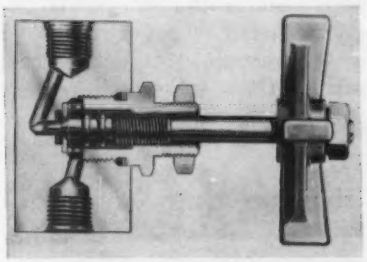


outer land-riding bronze retainer is designed for high strength, improved internal lubrication, and for higher operating speeds than possible with more conventional designs. Offered in ABEC-3 and ABEC-5 precision grades, bearings are made in extremely light, extra light, light, and medium series, in metric sizes up to 85 mm O.D. Standard material for rings and balls is 52100 steel. Four ranges of internal clearance allow designers a wide variety of operating characteristics. **Split Ballbearing Div., MPB Inc.**

Circle 89 on postcard for more data

Soft-Seat Needle Valve

Designed for gas or liquid, valve gives "bubble-tight" service up to 6000 psi. All internal parts may

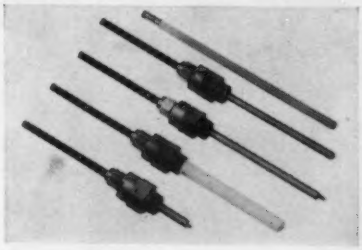


be dismantled and serviced without removing valve from the line. Sealing seat is Nylon, protected from abrasion by a metal retainer. All metal parts are stainless steel, except the handle, which is aluminum alloy. Synthetic rubber O-ring seals are protected by Teflon back-up rings. Operating temperatures range from —65° to 160°F with higher available on special order. **Republic Manufacturing Co.**

Circle 90 on postcard for more data

Thermocouple Probe

Thermocouple probe measures liquid and gas temperatures in the 1800°F range at pressures over 2000 psig. Unit is available in standard or special lengths. Models include exposed probes, those with



stainless steel sheaths, or ceramic sheaths for use with liquid metals and acids. Suitable for connection to low-temp Teflon or high-temp MgO cable. Constructed of chromel-alumel or chromel-constantan, are available with ⅝-18NF mounting thread and ⅞-in. hex body. **Technical Industries Corp.**

Circle 91 on postcard for more data

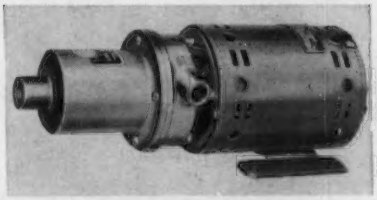
Gyroscope

Self-contained model NV3705, two-axis, torquer erected vertical gyroscope, is designed for aircraft and missile applications. Constructed of non-magnetic cast stainless steel, gyro is mounted to withstand high-level shock and vibration. Vertical reference is obtained by sensitive electrolytic switches; pitch and roll displacements are referenced by synchro pick-offs on the gyro axis. **Iron Fireman Mfg. Co.**

Circle 92 on postcard for more data

Pumps

Special-application small pump for liquids and abrasive slurries has no pistons, valves, or high-speed



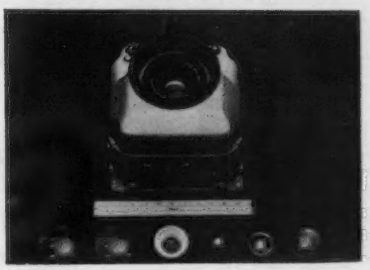
impellers. Only moving part is a stainless-steel helical-screw rotor turning within a fixed rubber stator. Deliveries range from metering flow to 1200 GPH; discharge heads range to 300 psi. **Robbins & Myers Inc.**

Circle 93 on postcard for more data

Aerial Camera Lens

Aerial camera, f/2.8 lens covers a field angle of 55 deg. Manufacturer claims 50 per cent better contrast characteristics and relative illumination over import previously used as measuring stick. Uses six elements in an asymmetrical arrangement with one aspheric surface. **Pacific Optical Corp.**

Circle 94 on postcard for more data



Here is a man you should know he's a DELAVAN FUEL INJECTOR SPECIALIST

James R. Brucker specializes in injection devices using flow controls. He's a Senior Project Engineer with Delavan. And during his six years of developmental experience, his products have become bill-of-material items on some of the world's most advanced jet engines for aircraft and missiles.

It's specialized engineering talent like Jim Brucker's that has made Delavan first choice for fuel injection problem solving. If fluid metering and atomization are part of your product, take advantage of Delavan's specialized experience and proven ability to deliver aircraft quality. Send specifications to the address below for obligation-free recommendations.

DELAVAN Manufacturing Company

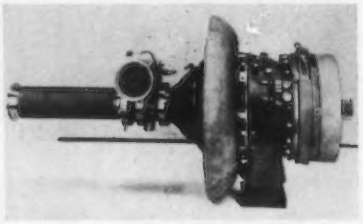
WORLD'S LARGEST MANUFACTURER OF NOZZLES • WEST DES MOINES • IOWA

Circle 37 on Inquiry Card

New Parts and Components

Starter-Motoring Unit

A 500-HP combination starter and motoring system for an aircraft nuclear powerplant weighs 150 lb. It will be used to bring the powerplant's turbomachinery up to self-sustaining speed in approximately one minute, and keep it turning



over during powerplant cooling at shutdown. Designated AW-10, starter is a pneumatic-powered device for operation in a radioactive environment. It will be operated on 700°F, 80 psia compressed air from a ground-power source or by engine cross-bleed in flight. **General Electric Co.**

Circle 95 on postcard for more data

Pressure Reducer

High pressure reducer for air or nitrogen weighs 8 oz., yet has high flow capacity.

Gas at 3000 psi can be reduced to 300 psi or to any pressure between 300 and 1800 psi by selecting proper spring.

Suitable for missiles and aircraft, assembly can be used in gyros, reaction jet, turbine control, and electronic pressurized systems. **Walter Kidde & Co.**

Circle 96 on postcard for more data

Bi-Propellant Valve

Normally-closed, explosive-actuated valve is for simultaneous opening of fuel and oxidizer lines. Materials are selected for use with UDMH and RFNA. **Pyronetics**

Circle 97 on postcard for more data

New Electronic Products

Variable Delay Lines

Linear, continuously - variable delay line cases and mechanisms are molded of high impact strength

plastic. Units will accept 1.0 microsecond elements and are continuously variable from .05 to 1.0 microseconds. Hermetically sealed, they comply fully with all environmental, shock and vibration requirements of MIL-E-5400C for airborne material and electrical equipment. **A-1 Precision Products.**

Circle 98 on postcard for more data

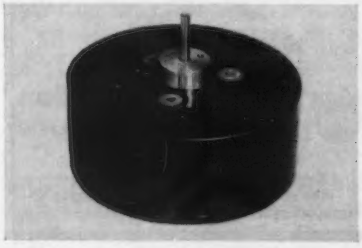
Infrared Scanner

"Filterscan" infrared scanning system is reportedly 30 times faster than mechanical systems for inspecting heat of components. Military applications are suggested by its being a "passive" system immune to jamming. **Philco Research Div.**

Circle 99 on postcard for more data

High Precision Motors

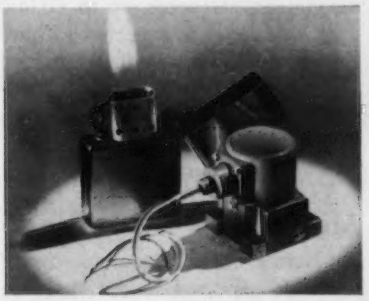
A new line of extreme precision hysteresis synchronous electric motors is now available. Motor-induced flutter will not exceed 0.1 rms at 1200 rpm or 0.15 rms at 360 rpm. Stray external magnetic field with a normally shielded head is held to —47 DBM. Motors will withstand temperature ambients from —32°C to 135°C, with extreme temperature-rated models available on special order. **Hysyn Electromotive.**



Circle 100 on postcard for more data

Five Ounce Servo

Miniature flow-control transducer weighs only 5 oz and is less than 1½ in. high. Unit offers high stability at extreme environments within a control flow range of .5 to



1.0 gpm. Other features include high temperature range to 450°F; operating pressure to 4000 psi; hysteresis 3 per cent max; threshold .5 per cent max. **Hydraulic Research & Mfg. Co.**

Circle 101 on postcard for more data

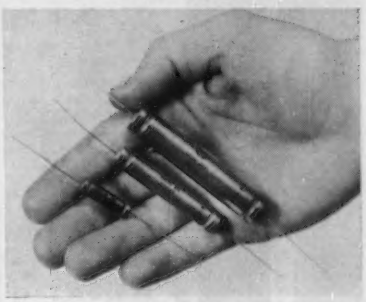
Tough Potentiometer

Helitrim trimming potentiometers utilize cermet resistance elements. Outstanding characteristics are: Infinite resolution; 1.5 watts power rating at 125°C ambient, derating to zero at 200°C; 2 ohms maximum end resistance; and zero backlash outstanding characteristics of the Helitrim. **Helipot Div., Beckman Instruments.**

Circle 102 on postcard for more data

Tantalum Capacitor

This 300 v foil-type tantalum electrolytic capacitor is believed the smallest unit of its kind in production. The Tantalytic units operate

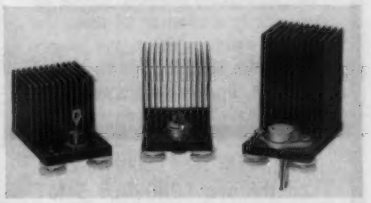


at 85°C (to 300v) and 125°C (to 250v). They are designed primarily for applications where minimum size and weight are major considerations. Capacitance tolerances are tightened to ±15 per cent compared to the ±20 per cent now standard with lower voltage units. **General Electric Co.**

Circle 103 on postcard for more data

Radiators

Line of semiconductor radiators allows a transistor, nominally rated at 10 watts, to be operated at 30



watts. The radiators are available in copper or aluminum. A surface machined flat to within 0.0002 in. is provided for mounting the semiconductors. Screw holes for mounting any semiconductor type can be provided. Plastic shoulder washers are furnished. **Wakefield Engineering Inc.**

Circle 104 on postcard for more data

Any frequency from 0.4 to 10.0 mc/s without tuning, by a simple change of transducers — with the most nearly perfect acoustical "picture" of internal structure obtainable today. And, as with all Branson products, service nationwide is assured at all times. For full information about the all-new SONORAY® Model 5, send the coupon today to Branson Instruments, Inc.

BRANSON: Send Bulletin T-203 on the new SONORAY® 5 to

NAME_____

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ADDRESS_____

BRANSON INSTRUMENTS, Inc.
58 Brown House Road • Stamford, Conn.

Circle 27 on Inquiry Card

New Electronic Products

Digital Encoder

Shaft-position digital encoder with 13 bit binary output employs a non-contacting magnetic readout.

Only bearings and gears affect life. This permits its operation in any environment, at speeds up to 10,000 rpm. Encoder is expected to have broad applications in digital control and data-logging equipment. **ASCOP, Div. of Electro-Mechanical Research.**

Circle 105 on postcard for more data

Microwave Mixer Diode

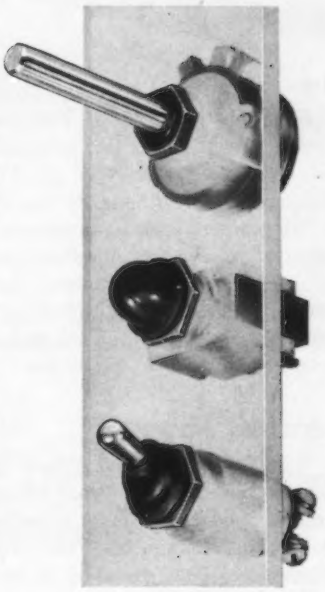
New L-band silicon microwave diode is expected to increase the performance and range of radar and missile tracking systems. Diode covers the top of UHF range to 1500 mc. Maximum conversion loss is only 5.5 db with a maximum output noise ratio as low as 1.5 times. This is the equivalent of a 13 per cent increase in range. **Sylvania Electric Products Inc.**

Circle 106 on postcard for more data

APM HEXSEALS®

Modular

SWITCH and SHAFT SEALS



- Fit all industrial electrical controls.
- Meet Military Specifications: MIL-B-005423A (ASG), MIL-B-19257 (Ships), SCL-6303 (Sig. Corps), Par. 183.10-20, Part (B) U.S. Coast Guard.

SEND FOR CATALOG 359A-1
describing items above, also seals for circuit breakers, indicator lights and other electronic components.

A. P. M. Corporation
252 Hawthorne Ave., Yonkers, N.Y.
YOnkers 8-2010

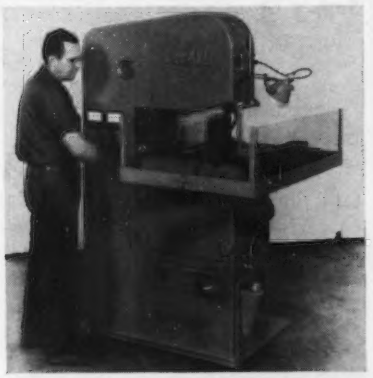
Designers and Manufacturers of
HIGH PRESSURE STATIC AND MOVABLE SEALS
HEXSEALS® • SEELSKREWS® • SEELBOLTS® • SEELRIVITS®

Circle 28 on Inquiry Card

New for Production

Honeycomb Slicer

Line of "Elector-Band" machines utilizes a new quenched-arc process for machining honeycomb.



This is an extension of the band-sawing technique. An energized band slices away a 1/32-in layer from a "log" of honeycomb. An electric arc at band's leading edge does actual cutting. This is aimed at saving time and material over the technique of grinding material from rough blanks. **The DoAll Co.**

Circle 107 on postcard for more data

Aircraft Welder

Dual-head spot welder with an 11 ft. reach is designed for the aircraft industry; spotwelds through stainless steel sections.

Welding electrodes are located at the extreme tip of the long, box-section arms, which may be set to operate in either the horizontal or vertical plane at constant height. **Precision Welder & Flexopress Corp.**

Circle 108 on postcard for more data

Metal Tester

Tester differentiates between inconel and stainless steel, zircaloy-2 and zirconium, and zircaloy-2 and hafnium. It consists of a standard milliammeter with two leads-one ending in a clamp and the other in a small carbon steel file. Operator holds metals in clamp and rubs the file against them. This generates a tiny current which indicates their type. **General Electric Co.**

Circle 109 on postcard for more data

Cavity Sinker

Cavity sinking machine tool applies the "Anocut" electrolytic metal removal principle to the sinking of irregular holes and shapes in exotic metals. The machine follows the contour of an electrode which is non-rotating. Electrode is plunged linearly into the work material. This principle was previously applied only where a rotating wheel could be used. **Anocut Engineering Co.**

Circle 110 on postcard for more data

Noise-cancelling Mike

"Speakeasy" noise - cancelling microphone and headset filters out noise, permitting normal communication in loud environments. The 34 oz unit is now in use in preflight checkouts of Braniff Airlines' jet airliners. It was also developed for jet test cells, machine shops, wind tunnels, and launch sites. **Chance Vought Aircraft**

Circle 111 on postcard for more data

Environmental Chamber

Environmental testing chamber measures 12 x 7 x 10 ft. Coverage includes 185°F, –90°F, climatic exposures to fungus, salt spray, sand and dust, sun, rain and humidity.

Chamber has a mechanical refrigeration system and a liquid CO_2 (25 ton) cooling system for large heat loads. **American Laboratories Div., American Electronics Inc.**

Circle 112 on postcard for more data

"Handy Hand"

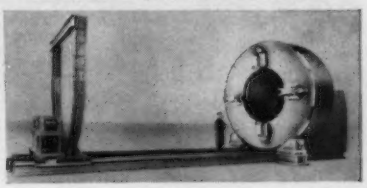
Device holds up to 3 lb of job weight during welding, soldering assembling or experimenting. Wide range of clamps includes magnifying glass and magnetic holders. Existing shop tooling fixtures are adaptable by attaching a 5/16 in spud for the revolving head. **Superior Welding Co.**

Circle 113 on postcard for more data

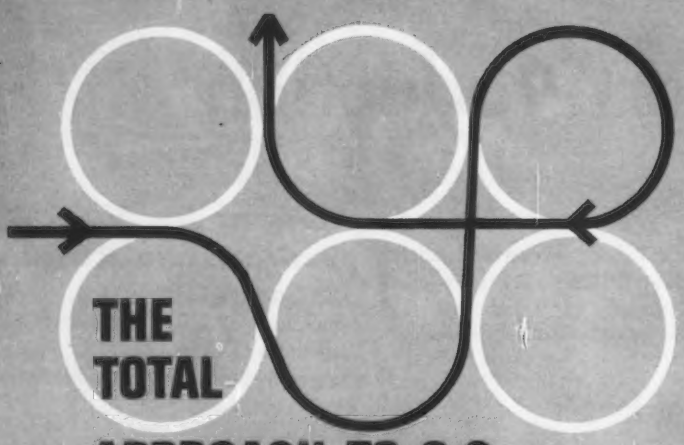
Swing Spinning Machine

This 80,000 lb machine has been installed at Aerojet-General's Sacramento plant. During oven curing of plastic coating, it handles parts up to 150 in diam., 36 ft length and 60,000 lb weight. **Raven Engineering Co.**

Circle 114 on postcard for more data



quality control engineers



THE TOTAL APPROACH TO Q.C.

...from conceptual realization of a product through obsolescence

It has long been the policy of General Electric's Ordnance Department to insure the operational capabilities of its products through a totally integrated quality control program.

Quality control starts at the proposal stage when a master Q.C. plan is formulated. As advanced design progresses, quality control engineers work closely with design groups in areas that will affect quality and production costs. Coincidentally incoming materials are subjected to rigid quality controls and continuing liaison is maintained with vendors to insure maintenance of specifications. As a product moves into the production phase continuous monitoring of manufacturing processes is performed, not only to certify previous reliability criteria but with a view to improving product capabilities through institution of better production procedures. Cost-production evaluation is also carried out to prove feasibility of any given Q.C. plan on an individual product.

Immediate openings for experienced Q.C. Engineers on such programs as Torpedoes... Other Underwater Weapons... Fire Control Directors... Missile Launching and Handling Equipments... Inertial Guidance Equipments... Navigational Equipments...

If you possess a degree in engineering and from 3 to 12 years experience in quality control, we invite you to investigate these openings:

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Q.C. ENGINEER—COMPONENTS
Q.C. ENGINEER—SYSTEMS

Applicants for these positions should have a BSEE, BSME or BS in Physics with emphasis having been placed on electronics. Must be able to work well with other people and analytical ability to reach sound solutions to problems. It is desirable to have some Fire Control and/or Radar experience and also be familiar with digital techniques, printed boards and transistorized circuits.

Please forward your inquiries including salary requirements in complete confidence to:
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ORDNANCE DEPARTMENT
of the Defense Electronics Division

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New for Production

Plastic Safety Suit

Disposable plastic safety suit resists most acids and alkalis. It is fireproof, waterproof, and unaffected by oil or grease. Slip-over jacket and trousers are light yellow polyvinyl chloride. **Safety First Supply Co.**

Circle 115 on postcard for more data

Slide Chart

Handy slide chart gives important dimensions of screw threads, or parts such as AN bolts, screws, nuts, washers. Parts are fundamental ones often used by aircraft and missile designers. **Elemoto Sales Co.**

Circle 116 on postcard for more data

Ellipse Protractor

New ellipse protractor permits artists, illustrators and technical draftsmen to make rapid projections without trigonometry tables. It is credited with saving 8000 manhours at Rocketdyne. **Navan Products**

Circle 117 on postcard for more data

Impulse Tester

High-temperature impulse test machine for hydraulic components provides hydraulic pressure to an operating level of 5000 psi with 7500 psi surges. Environmental conditions within test chamber can be varied from –100°F to 600°F. Liquefied CO_2 is normally used for cold-environment operation. Chamber has an ultimate low temperature capability of –300°F using liquid nitrogen as coolant. **Resistoflex Corp.**

Circle 118 on postcard for more data

Men on the Move

RICHARD M. CLARKE, named sales manager of Joclin Manufacturing Co.

G. W. RUTHERFORD, named a vice president of Ryan Aeronautical Co.

JOHN J. MCDONALD and LINDEN G. CRIDDLE, elected vice presidents of Consolidated Systems Corp.

EDWARD L. MONTGOMERY, appointed executive assistant to the vice president and general manager of Aeronutronic, Div. of Ford Motor Co.

DR. LELAND G. COLE, appointed vice president-research for Beckman Instruments, Inc.

T. W. SHINAFELT, appointed to direct the Quality Control and Service Departments at the Aeronautics Div., Chance Vought Aircraft. H. WILLIAM THOMAS, has joined the Astronautics Div. as market development manager.

RAWSON L. WOOD, elected chairman of the board of Arwood Precision Casting Corp., formed by merger of Mercast Manufacturing Corp. and Alloy Precision Castings Co. WILLIAM I. MATHES, elected president of Arwood.

ROGER H. B. DAVIS, appointed comptroller of the Fairchild Engine and Airplane Corp.

ROBERT D. FORGER, appointed administrative assistant on the National Office Staff, Society of Plastics Engineers, Inc.

JACK L. BROMBERG, appointed program manager for Nike Zeus activities at Douglas Aircraft Co. A. F. PUGLISI, appointed chief engineer of the Tulsa Div.

DR. ERWIN O. A. NAUMANN, appointed manager of development in the research and development engineering division at Solar Aircraft Co. WILLIAM C. BENSON, promoted manager of ground support equipment sales at Solar.

KERMITH F. WASMUTH, named director of Martin-Denver's Quality Control Div.

JACK KATZEN, appointed manager of engineering administration and integration at General Electric's Missile and Space Vehicle Dept.

HENRY JACOBI, appointed president of the Defense Products Div., Brunswick-Balke-Collender Co.

PHILIP S. HESSINGER, named manager of research of National Beryllia Corp., working in research and development relating to beryllium oxide and other pure metal oxide ceramics.

GLENN CATO has joined Electro-Optical Systems, Inc., as a senior engineer in the Space Defense Systems Div.

DAVID A. HILL, named manager of the semiconductor division of Hughes Products Group. LLOYD H. SCOTT, appointed manager of Santa Barbara Research Center; L. JAMES LEVISEE, named director of material, general office. DR. NORMAN A. BAILY, has joined the company's nuclear electronics laboratory as a senior staff physicist.

CONRAD KUNZE, appointed assistant manager, operations, for Convair-San Diego.

D. F. SANDERS, named president of Lockheed Electronics Co. new Lockheed subsidiary.

EMERSON S. REICHARD, JR., appointed vice president administration; ELMER NELSON, named asst. to the president; at Aerojet-General, Sacramento. JEROME C. JOERGER, named manager of Aerojet's Aeronautical Div.

DR. J. ROBERT DOWNING, named president of Space Recovery Systems, Inc.

Dr. Leland G. Cole
Beckman Instruments

T. W. Shinafelt
Chance Vought

Kermith F. Wasmuth
Martin-Denver

Jack Katzen
General Electric-MSVD

Conrad Kunze
Convair-San Diego

D. F. Sanders
Lockheed Electronics

Rawson L. Wood
Arwood Corp.

Roger H. B. Davis
Fairchild

Henry Jacobi
Brunswick-Balke-Collender

Philip S. Hessinger
National Beryllia Corp.

Emerson S. Reichard Jr.
Aerojet-General

Dr. J. Robert Downing
Space Recovery Systems

Industry Notes

A Corporation Looks Ahead

Major General John W. Sessums (USAF ret) discusses how Grand Central Rocket Co. is planning for the future in this interview by Aircraft & Missiles' West Coast editor, Philip Geddes. General Sessums is former Vice Commander of the Air Research and Development Command and now Chairman of the Board of Directors at Grand Central.

Q. In what areas will Grand Central Rocket Co. concentrate in the next three to five years?

A. We intend to direct our efforts into two main channels. First, producing large solid booster rockets, capable of putting large payloads into space. Second, taking solid propellants out of the "custom built" class.

Most solid propellant manufacturers think that a big booster can be made in 12 to 18 months. We are among several companies about to submit a proposal for an Air Force contract for a one million pound thrust unit. This is proof of our confidence in the future of large solid propellant motors. Until now, making solid rockets has been like a ladies' hat shop operation . . . there, everything is custom built. One batch of materials is entirely different from the next. Many checks and tests are required during mixing operations. We want to take the uncertain elements out of making our end-product and at the same time lower costs.

Maj. Gen. J. W. Sessums

Q. How do you expect to achieve your goals in simplifying processing and lowering costs?

A. We have to apply automation to our standard processes, as our greatest single cost after development is labor. Our advance market planning will determine which solid motor size has the greatest application. We will then set up an automated line and continuous mixing process. Production will have some flexibility about this standard size—our "fixed price line." We know that the Army has a well-established requirement for rockets which can shoot small, highly-destructive payloads. We also feel that universities are going to do a lot of research on space problems. Their needs will give us a market for a low-cost solid device for shooting probes.

The effect of production on cost can be seen by looking at the standard 2.75-in. Air Force/Navy rocket

POLARIS FIRING SYSTEM is tested at General Dynamics' Electric Boat Div., Groton, Conn. Mushroom-like tower of water rises from one of 16 missile tubes. Nuclear sub George Washington fired one-ton test cylinder, obscured by water column.

developed by the Naval Ordnance Test Station. Approximately 15 million of these rockets were made at a cost of about $7 each, propellant cost.

The inert parts of the solid motor such as case and nozzle can also be standardized to reduce costs.

In the automated line we were discussing, an automatic case-loading system will be developed to fill rocket chambers in much the same way soft drinks are put into bottles. A conveyor belt can be developed for passing the motors through their cure cycles just as automobile manufacturers do their painting.

Q. What are the principal problems in the solid propellant field and what are you doing about them?

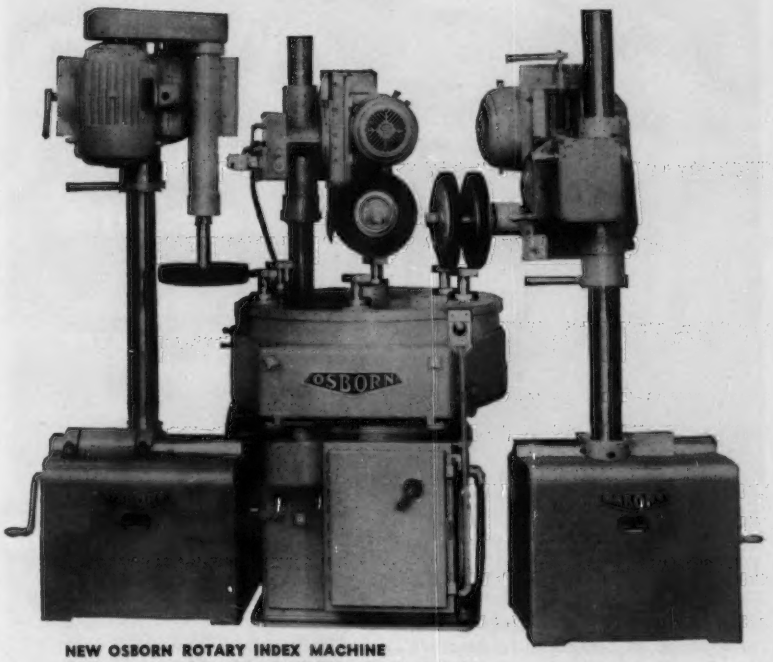
A. Our problem is to catch up and try to pass liquid propellant systems in specific impulse. We have to learn to stabilize our propellants. The Air Force specifies cold cycling from –65°F to 135°F. The shrinking which takes place at low temperatures must be overcome. We must build an off-on capability into our motors. Our scientists predict this capability will be accomplished in three years; I am more optimistic and predict 2 years.

Progress has been made with all these problems. Specific impulse of existing solid propellants is now as high as 240 sec. Lab batches of solids are achieving 280 sec. In the past, synthetic rubber was used extensively for polymerizing solid propellants. New plastic materials and resins will help us overcome present-day shrinking and cracking problems. We want to arrive at the point where the coefficient of expansion of the case and propellant are the same.

I can visualize a large booster, some 10 feet in diameter. Some authorities were predicting that launch-site mixing facilities would be necessary for a large solid booster rocket. I am not in agreement. The state of the art is going to advance a considerable distance as more effort is put into solid fuels. We can also cluster our smaller boosters.

To cut your metal finishing costs...

NEW— OSBORN ROTARY INDEX MACHINE



NEW OSBORN ROTARY INDEX MACHINE
Units can range from manual to fully automatic operation

Unique "building block" design means unlimited production flexibility

NEWEST ADDITION to Osborn's broad line of metal finishing machines are these Rotary Index units. Capability: significant increase of your production capacity.

Most important feature—production men can economically "build" *custom* metal finishing machines from *basic "building block"* components . . . finishing heads, index tables and electric controls. Other advanced design and construction features make these new Osborn Metal Finishing Machine units worth your immediate investigation.

Your Osborn field specialist has latest application data on a wide range of cost-saving finishing methods. And an Osborn Analysis—made in your plant—is the first step to pinpoint savings on *your* operations. Write for details. *The Osborn Manufacturing Company, Dept. AM-8, Cleveland 14, Ohio.*

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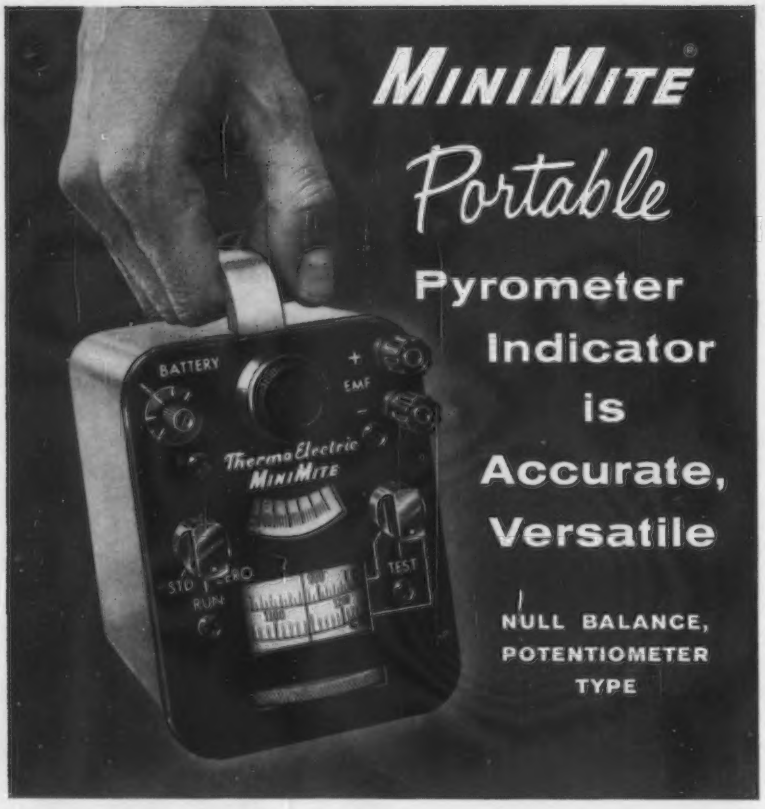
METAL FINISHING MACHINES... AND FINISHING METHODS
POWER, PAINT AND MAINTENANCE BRUSHES
FOUNDRY PRODUCTION MACHINERY

OSBORN



The "MiniMite" Portable Pyrometer Indicator gives you laboratory accuracy—in a rugged, versatile instrument. You can use it dependably for a wide range of temperature measurement, calibration and test purposes. Carry it around and set it up wherever you need it. Heavy use won't impair its performance or accuracy.

Temperature Measurement

When connected to a thermocouple the "MiniMite" will measure temperature directly. Use it for laboratory work, emergency operation, or as a substitute for instruments under repair. It's also ideal for a wide variety of research and test work. Automatic cold-junction compensation is built-in.

Calibration

You can use the "MiniMite" to check the calibration of thermocouples and potentiometer-type instruments. When connected to a variable voltage supply, the "MiniMite" can check millivoltmeter-type instruments.

Scale Range

Despite the "MiniMite's" small size, individual ranges on its double-range scale are almost 24" long. A choice of 53 different range combinations covers temperatures from —300°F. to +3200°F. for Copper-Constantan, Iron-Constantan, Chromel-Alumel and Platinum-Rhodium-Platinum—and millivolts from —6.2 to +62. Accuracy is ¼ of 1% of scale range.

Convenience

The "MiniMite" measures only 4" x 5" x 6" and weighs under 4 lbs. It will function in either horizontal or vertical position. Widely spaced graduations permit easy, accurate readings. Cold-junction compensation can be cut in or out by a single switch.

Immediate Delivery

"MiniMites" with the 13 most popular double-range scales are available for immediate delivery. For other ranges—3-4 weeks' delivery.

Write for Bulletin 64-1

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

Industry Notes

Business Moves

The **Budd Company's** Defense Div. is now named SpaceAtomics Div. Budd's Tatnall Measuring Systems Div. and Nuclear Systems Div. have been merged into a single entity, named Instruments Div.

New Advanced Propulsion Div. of **Aerotest Laboratories** is located at gas turbine lab which Aerotest acquired from Fairchild at Deer Park, L. I.

Douglas Aircraft has established the Douglas Computing Service to sell excess computing-machine time outside the company.

Aero - Space Div. has been created at **Walter Kidde & Co.,** Belleville, N. J.

Martin Co. is consolidating Titan work under a single integrated division at its Denver plant.

Rockwell - Standard Corp. will consolidate all R & D activities at Birmingham, Mich.

Atlantic Research Corp. has begun a new operation—testing rocket materials for manufacturers.

Robinson Technical Products Inc., Teterboro, N. J., and **Kensico Tube Co. Inc.** announce that agreement has been reached upon a merger. Kensico would become a division of Robinson.

Key Electronics Inc., Hollywood, Calif., has been appointed manufacturer's representative for Bill Jack Scientific Instrument Co.

United Aircraft Products, Inc. announced purchase of assets of Western Way Welding, Gardena, Calif. and its immediate establishment as the firm's Western Div.

Small Tools Div. for the marketing of micro-miniature cutting tools is new unit at **Waltham Pre-**

Contracts

The Air Force awarded Autonetics Div., North American Aviation, a $150-million contract for R & D on Minuteman inertial guidance and flight control.

Martin received a $22.6-million Navy contract for continued production of Bullpup with pre-packaged liquid powerplant. The Army awarded Martin $10,500,000 for continued R & D on Pershing. Martin - Baltimore received $37,000 from the Navy for research in biophysical aspects of photosynthesis.

A $58-million Navy contract for continued production of F8U-2N Crusaders was awarded the Aeronautics Div., Chance Vought.

A $73-million letter contract for A3J-1 Vigilante production during 1961 was signed by the Navy and North American Aviation.

The Navy awarded Grumman Aircraft $26,300,000 for additional WF-2 TRACER production.

The Air Force awarded Cessna Aircraft $9.5-million for production of T-37B intermediate jet trainers through July 1961.

Other contracts:

◆ $8,911,904 Army contract to RCA's Moorestown N. J., division for the down range anti-missile measurement program.

◆ $175,000 McDonnell subcontract to Donner Scientific Co. for maximum altitude sensors to be installed in the Mercury capsules. Device energizes devices for separating the escape tower under abort conditions.

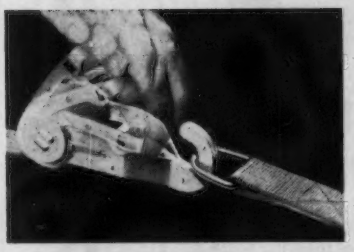
◆ $2,732,000 Navy contract for producing five electronic flight and tactics simulators went to the Erco Div., ACF Industries. Simulators will incorporate latest tactical equipment for antisubmarine warfare.

Convair/Pomona awarded Atlantic Research $400,000 for development of the two-step rocket for the Red-Eye antiaircraft missile.

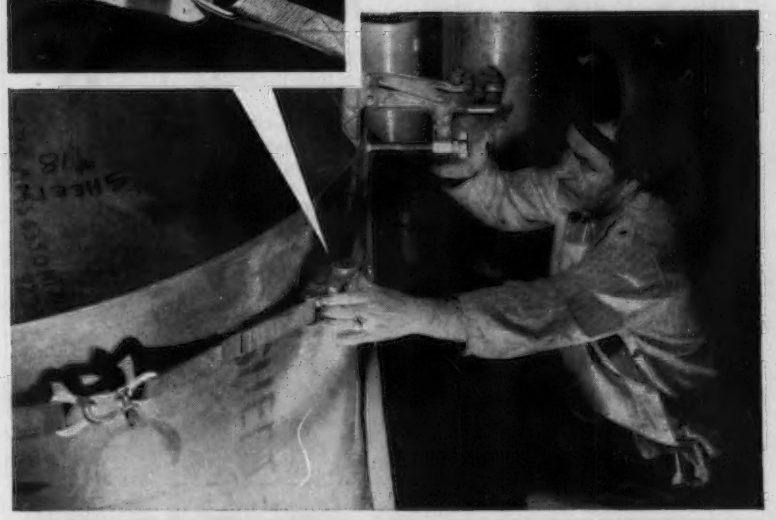
Industry proposals are due this month in Navy Bureau of Weapons competition for the carrier-based Missileer which would carry Eagle missiles.

Aeroquip Ratchet Buckle and Webbing Eliminates Expensive Jigs and Fixtures

—SAVES TIME DURING FABRICATION OF SHEET METAL



CURTISS-WRIGHT WELDS ROCKET MOTOR CASES POSITIONED WITH AEROQUIP STRAPS



Accurate positioning of these large steel sheets are assured by the infinitely adjustable ratchet buckle. The high-strength strap and buckle assembly has a rated strength of 5000 lbs.

Aeroquip Web Straps with Ratchet Buckles are used to simplify production of rocket motor cases at Curtiss-Wright Corporation's Wright Aeronautical Division. Rolled steel is held by the straps in cylindrical form for welding, as pictured. The ratchet buckle operates as a miniature winch, tensions to 500 pounds, offers infinite adjustment, easy tensioning and quick, safe release of the web strap.

Aeroquip manufactures a wide range of straps and buckles and high strength chain and cable tie-downs.

If you have a materials handling problem involving tie-down or positioning of large structural materials, let Aeroquip engineers save you time and money. Mail the coupon below for details.

Aeroquip

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GENERAL LOGISTICS DIVISION

2929 FLOYD STREET, BURBANK, CALIFORNIA

AM-2

Please send me details on Aeroquip materials handling products checked at left:

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Soldering is EASIER FASTER BETTER with American Beauty Soldering Tools

American Beauty electric soldering irons are the highest quality made. The finest engineering, best materials and on-the-job experience since 1894 is yours with every American Beauty. There is a right model, correct tip size and proper watt input to do any soldering job easier, faster and better.

TEMPERATURE REGULATING STANDS
Automatic devices for controlling tip temperatures while iron is at rest—prevents overheating of iron, eliminates frequent retinning of tip, while maintaining any desired temperature. Available with perforated steel guard to protect user's hand.

201-B

WRITE FOR 28-PAGE ILLUSTRATED CATALOG CONTAINING FULL INFORMATION ON OUR COMPLETE LINE OF ELECTRIC SOLDERING IRONS—INCLUDING THEIR USE AND CARE.

AMERICAN ELECTRICAL HEATER COMPANY
DETROIT 2, MICHIGAN

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Industry Notes

Aerospace Log

Dec. 15—F104C piloted by Air Force Capt. Joe B. Jordon, reaches 103,395.5 ft., new world's altitude record. Flown from Edwards Air Force Base.

Dec. 16—Third test model of Nike Zeus fired at White Sands. Second stage failed when sustainer motor did not ignite.

Dec. 16—Ground-guided Snark ICBM completes third 2000 mile round trip over Atlantic Missile Range from Cape Canaveral.

Dec. 16 — Air Force claims 1520.9 mph world speed record for F106 Delta Dart equipped with afterburner. Maj. Joseph W. Rogers flew the ship at Edwards Air Force Base.

Dec. 22 — Four-stage Javelin rocket shoots 48-lb payload 560 miles high. Firing from Wallops Island studies radio waves, tests new X-248 solid fuel rocket engine to be used in Scout and Delta.

Dec. 23—Polaris fired from ship motion simulator. Sixth firing of prototype.

Jan. 6—Atlas ICBM fired 5550 miles—first 1960 shot.

Jan. 7—Polaris fired successfully 900 miles.

New Facilities

Rocketdyne established a new major product organization called Liquid Propulsion operations. It will be headquartered in Canoga Park.

Army's Kansas Ordnance Plant at Parsons, Kan., will be operated by **Grand Central Rocket Co.** Facility will produce and load solid —propellant motors, concentrating on the 5000 to 10,000-lb-thrust range.

Leemath Inc. acquired a 60,000-sq ft precision sheet metal shop in South Portland, Maine. Firm plans to operate it as a subsidiary which will investigate use of beryllium in sheet-metal assemblies.

Acoustical test laboratory just established at **Sargent Engineering Corp.** will conduct noise evaluation and noise reduction studies on hydraulic, mechanical and electromechanical equipment.

American Metal Products Co. recently opened its Engineering Science Div. building at Ann Arbor, Mich. Aim is to find and develop new uses for rare and exotic nuclear fuels and high-temperature materials.

Convair is directing electrical modifications of the Sycamore Canyon Atlas missile test site, 20 miles northeast of San Diego. Existing power and control systems are being changed to meet the requirements for static firing of the new Series "E" Atlas.

R & D Briefs

Harvey Aluminum, operating the Wright Air Development Center metals processing facility, is now studying the **metal-working characteristics of molybdenum and tungsten.** Niobium and tantalum fabricability will also be studied.

Compact, electronic, **automatic-switching device** to speed information from missiles and satellites to ground installations has been developed by Electronic Systems Development Corp., subsidiary of Solar Aircraft.

Research, development and production contracts for new **lightweight rocket nozzle and rocket motor cases** for Polaris have been awarded to Solar Aircraft Co. by Aerojet-General Corp.

Lightweight **anti-skid braking system,** described as a major advance in controlling highspeed airplane landings, has been developed by Bendix Aviation.

ICBM-tracking radar capable of identifying warheads is being developed by Raytheon Co.

Production Techniques

North American rights to a new **electron-beam process** developed by the Carl Zeiss Foundation of West Germany for machining or welding hard materials have been acquired by Hamilton Standard, division of United Aircraft Co.

New **high temperature superalloy** has been developed by American-Marietta Co. and its subsidiary, Sierra Metals Corp. It is being used in jet engine production.

Lodge & Shipley announces further development and expansion of the "Flo-Reforming" process. The new process is termed **"Multi-Flo-Reform."** It handles substantially longer parts.

New methods for safer continuous **processing of solid propellants** is being developed by Rocketdyne. Pilot plant with capacity of 500 lb. of propellant per hr. is transportable.

Precision Saw With Air Clamps Makes Clean Cuts..Reduces Waste & Machining

FOR
Stainless
Aluminum
Magnesium
Copper
Glass

Rough edges left from shearing and inaccurate saws pile up needless machining bills . . . plus the cost of wasted metal. With this new Ty-Sa-Man 144-BD Saw, adjustable air clamps hold metal down while the saw travels down the machined transverse rail, delivering cuts with smooth edges to amazing tolerances. Cut parallel strips . . . handle difficult jig fixture work with this self-contained saw which has its own integral cooling system and tank. Among its features are a calibrated guide fence, infinite variable speed from zero to twenty FPM, push-button control and 15 HP motor.

Ty-Sa-Man
SINCE 1885

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TY-SA-MAN Machine Co., Inc.
1135 White Ave., Knoxville, Tenn.

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ground dias. ±.0001
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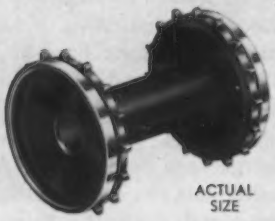
TOOTH REQUIREMENTS:
16 teeth each flange
Tooth form radius ±.0005
equally spaced within .00015
All 4 corners of tooth broken .005 min. from tip to root completely burr free



ACTUAL SIZE

This is typical of the unique field in which LaVezzi has specialized for over 50 years. Your small high precision machine work can be expertly accomplished by the skilled personnel and fine facilities at LaVezzi. Your inquiries are earnestly requested. Facilities list and brochure upon request.

LaVezzi MACHINE WORKS

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how to do more work in an hour

...with no strain

Model 400-GP Lightweight Sander

Model 400-RS Reversing Screwdriver

Powerful Airetool pneumatic production tools help workers do the same jobs faster . . . yet they are so perfectly balanced they reduce operator fatigue. The lightweight sander illustrated above is also available in straight-type design with lever throttle. Airetool's complete line of pneumatic screwdrivers includes straight design as shown and pistol grip models with reversing and non-reversing drives. Why don't you find out how these tools will cut your costs? Write for plant demonstration or Catalog No. 63.

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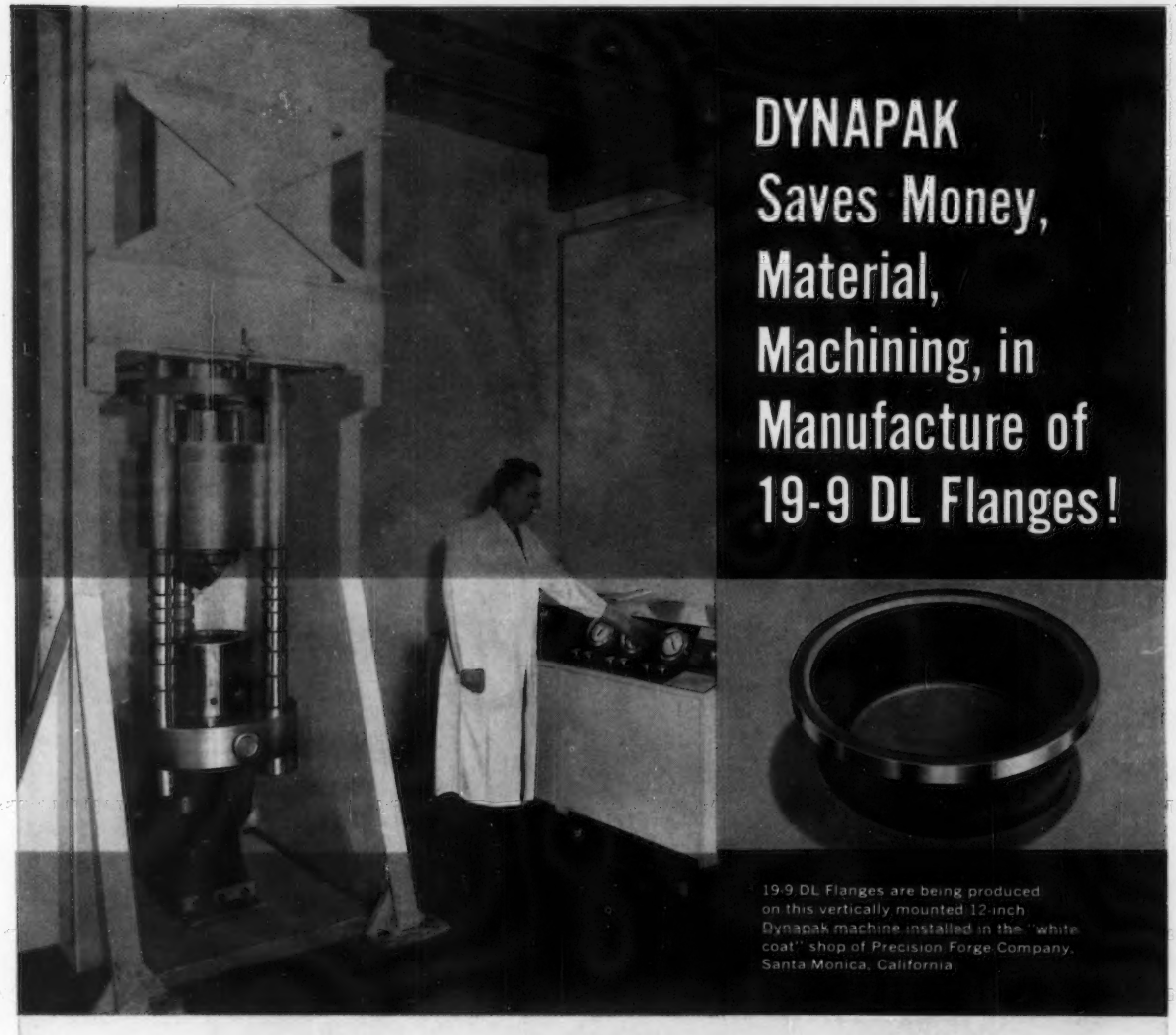

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19-9 DL Flanges are being produced on this vertically mounted 12-inch Dynapak machine installed in the "white coat" shop of Precision Forge Company, Santa Monica, California

Here are the savings achieved in this Dynapak Application:

- MATERIAL: 60%
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Presses, like the above, are also well suited to low temperature plastic laminating.

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